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ORIGINAL ARTICLES.

I.—A New Egyptian Mammal (*Arsinöitherium*) from the Fayûm.

(PLATES XXIII AND XXIV.)

FROM time to time during the last two years brief accounts of a remarkable series of vertebrate remains, from the Middle and Upper Eocene of the Fayûm district of Egypt, have been published in the pages of this Magazine. The species hitherto described include a number of highly interesting animals, but of the most extraordinary of all, viz. *Arsinöitherium Zitteli*, no figure has yet appeared in this Journal. We are therefore glad to take the opportunity of remedying this omission by availing ourselves of the kind permission of the Editor of *The Sphere* to reproduce two photographs of the skull of this animal, which appeared in the pages of that journal on September 12th, 1903, as illustrations of a short article by Professor E. Ray Lankester, which is the first account of *Arsinöitherium* published in this country, and from which some extracts are given below.

Arsinöitherium Zitteli was found about two years ago by Mr. H. J. L. Beadnell, who published in Cairo a preliminary notice with figures of the type skull and some other specimens.[1] Since then more complete specimens have been found both by him and by Dr. C. W. Andrews, and it is one of these, now in the British Museum of Natural History, Cromwell Road, London, of which photographs are given. A complete account both of this and of the other extinct animals of the Fayûm will be shortly published in a monograph, which will include figures and descriptions of the material both in London and Cairo.

The deposits in which these remains occur have been described by Schweinfurth, Beadnell, Blanckenhorn, and others. The lower beds, consisting mainly of clays, sandstones, and limestones, are for the most part of marine or littoral origin, while the upper beds,

[1] Survey Department Public Works Ministry, Cairo, 1902. A preliminary note on *Arsinöitherium Zitteli*, Beadn., from the Upper Eocene strata of Egypt. By Hugh J. L. Beadnell, F.G.S., F.R.G.S.; 8vo; pp. 1–4, pls. i–vi.

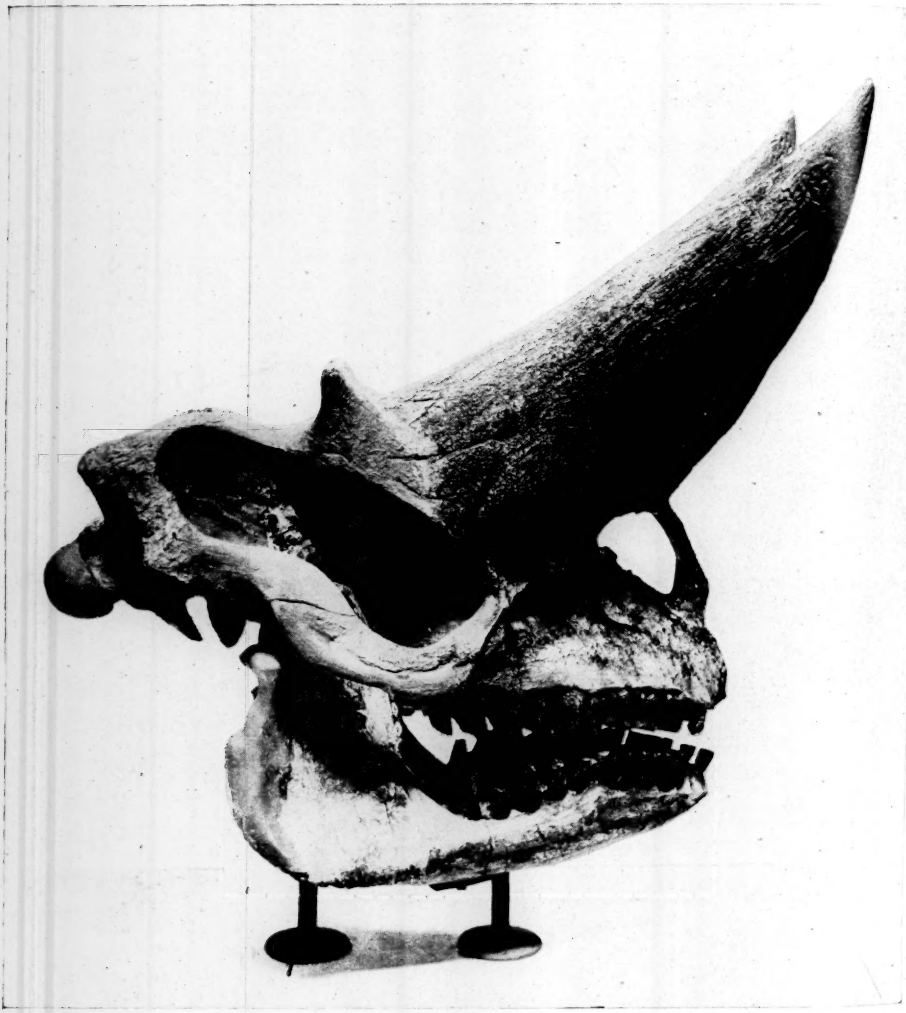
from which *Arsinöitherium* and *Palæomastodon* were collected, consist mostly of current-bedded sands of fluviatile or estuarine origin; in places these include great quantities of silicified tree trunks, which no doubt were brought down by the same stream which bore to their present resting-places the carcases of the animals whose remains are now being found. These deposits probably mark the position of the estuary of a great river, coming from a more or less southerly direction and draining a land area the fauna of which we are only now beginning to know. The first land mammals were collected less than three years ago, but, as mentioned in the following extracts from Professor Lankester's article, the work is still going on :—

"The officers of the Egyptian Survey have continued their exploration of the region, and in addition Dr. Andrews has also been sent both last year and again this year in the spring months by the Trustees of the British Museum to dig in the sands of the desert in search of further remains of this marvellous assemblage of strange and long-since vanished animals. The journey into the desert is not a light task, as the best localities discovered are as much as three days' march from any supply of water. Last year Mr. Beadnell, of the Egyptian Geological Survey, discovered what is perhaps the most astonishing of all the monsters unearthed in the Fayûm. It is as big as a large rhinoceros, and at first sight the skull suggests an affinity with that animal. It has two enormous horns growing from the nasal bone, but these are not, as in the rhinoceros, horns of a horny, fibrous material; they are actual bony outgrowths covered in life with blood-vessels and skin, and probably hair, as are the horns of the giraffe. Possibly the tips of these two great horns may have been protected by a sheath of horny matter, like a cow's horn. To this monster Mr. Beadnell has given the name *Arsinöitherium*, in honour of the Egyptian queen, Arsinöe, who had a palace in the Fayûm in a region near the Lake Moeris, which was larger in those days and surrounded by a fertile zone, degenerated into sandy waste since her time.

"Since Mr. Beadnell's discovery of the first skull of *Arsinöitherium*, some six or seven more or less complete skulls have been dug out. The most complete, having the lower jaw actually belonging to it in place, is that shown in the photograph. It was recently brought home by Dr. Andrews from Egypt, and after cleaning, strengthening, and the restoration of parts deficient on the left side by modelling from the right side, is now exhibited in the central hall of the Natural History Museum in Cromwell Road.

"It will be seen from our photographs that besides the huge pair of horns projecting forwards above the nostrils, *Arsinöitherium* had a smaller pair of horns lying further back upon the skull.

"The nearest allies, it seems, of the great horned beast of the Fayûm are to be found in a set of animals of which the best known has the name *Dinoceras*, discovered in Wyoming, North America, in sands of the same age as those of the Fayûm. These *Dinoceras* forms have been obtained in some abundance, and were made the



Profile of Skull of *Arsinöitherium Zitteli*, Beadn.

Upper Eocene, Fayûm, Egypt.

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subject of a monograph by the late Professor Marsh, of Yale. They are as large as a large rhinoceros, and have as many as three pairs of horns; none, indeed, quite so big as the front pair of *Arsinöitherium*, but often of respectable size. Many kinds are known, and the complete skeleton has been put together. They form a group known as the Amblypoda, and it is recognised as characteristic of this group that the feet and limb bones are similar in character to those of elephants. The teeth are very different from those of *Arsinöitherium*. A full-sized model of a complete skeleton of a *Dinoceras* is exhibited in the east gallery of the Natural History Museum. It is probable that the Amblypoda and *Arsinöitherium* are representatives of a group of great mammals which sprang from ancestors common to them and to the elephants—before the peculiar tusks and the trunk of the elephant had been developed. The hollow brain-case of *Arsinöitherium* has enabled us to study the shape of its brain by means of casts, and this will throw light on its affinities with elephants and *Dinoceras*.

"The question naturally arises as to what was the special use to *Arsinöitherium* of its two huge horns. The use of horns is in almost all cases either for defence against animals of prey or for those fierce contests between the males of a species in which the victor becomes lord of a number of females. Possibly both purposes were served by the horns of the *Arsinöitherium*.

"The skulls and bones of *Arsinöitherium*, described by Mr. Beadnell, belong to a single species to which he gave the name *A. Zitteli*, after Professor Zittel, of Munich. The lower jaw of this species is 1 ft. 8 in. in length. To this species belongs the specimen figured in the photograph, and it is a sufficiently huge and astonishing monster. But Dr. Andrews has this year brought back from the Fayûm a lower jaw of an *Arsinöitherium*, which is one-third as large again, namely, 2 feet in length (73·5 cm.). There is no doubt that this is a distinct and larger kind of *Arsinöitherium*, much bigger than the biggest existing rhinoceros. I name it *Arsinöitherium Andrewsii*, in recognition of the remarkable ability, courage, and perseverance shown by Dr. Andrews in the elucidation of the fossil mammals of the Fayûm."

It may not be inappropriate to mention that for the carrying out of Dr. Andrews' last expedition to the Fayûm, which resulted not only in securing a valuable series of vertebrate fossils, but the especially fine and complete head of *Arsinöitherium Zitteli* and the jaw and portions of the cranium of *Arsinöitherium Andrewsii*, the National Museum is indebted to the liberality of that enthusiastic naturalist W. E. De Winton, Esq., F.Z.S., for some time past the very able Acting Superintendent of the Zoological Society's Gardens, Regent's Park.

EXPLANATION OF PLATES XXIII AND XXIV.

PLATE XXIII.—Profile of skull of *Arsinöitherium Zitteli*, Beadn., from the Upper Eocene of the Fayûm, Egypt.

The dotted white line on this Plate indicates the extreme length of the mandible, viz. 20 inches.

PLATE XXIV.—Front view of skull of *Arsinoïtherium Zitteli*, Beadn. Upper Eocene, Fayûm, Egypt.

The dimensions of the skull here figured are approximately as follows:—

	cm.
Extreme length from occipital condyle to tip of horn	99
,, ,, ,, ,, of snout	76
Width between outer ends of occipital condyles	25
Width at zygomatic arches	33·5
Width between tips of small horns	26
Length of mandible	about 53·5

The dimensions of the type of *Arsinoïtherium Andrewsii*, Lankr., are roughly:—

	cm.
Length of mandible	73
,, lower molar series	23
,, premolar series	14
,, upper molar series	23·5

The above specimens have been presented to the Trustees and are now exhibited in the Great Central Hall of the British Museum (Natural History), Cromwell Road, London, S.W.

II.—THE NEW GEOLOGICAL MUSEUM AT CAMBRIDGE.

By F. R. COWPER REED, M.A., F.G.S.

THE Geological Department at Cambridge is at length provided with adequate accommodation by its transference to the new Sedgwick Memorial Museum. The portion of Cockerell's Building formerly occupied by the Woodwardian Museum has been vacated and put at the disposal of the University Library; and the well-known name is only perpetuated in a special portion of the exhibition galleries in the new building containing the founder's collection.

The Sedgwick Museum is the second Geological Museum at Cambridge which has been erected mainly through the liberality of the public. For, when in 1835 it was decided by the University to build a museum for geology, the sum of £23,400 was collected by public subscription, and to this was added £4,000 of Woodwardian Trust money. Cockerell's Building was erected with the help of these funds, and to the geological collections were assigned the two lower floors. The inadequacy of this accommodation, owing to the growth of the department and the increase in the size of the collections, has been only too apparent for many years. On the death of Professor Sedgwick in 1873 it was decided that his memorial should take the form of a new and larger museum; and in that year a public subscription was opened for this purpose, and a sum raised which ultimately amounted to over £28,000. The public recognition of the value of the Geological Department at Cambridge has thus been shown in a very substantial and liberal manner on two occasions.

After a long series of disappointments and difficulties the indefatigable energy and perseverance of Professor Sedgwick's successor, Professor T. McKenny Hughes, have triumphed over the countless obstacles which hindered the realisation of the scheme. The history of the efforts which have been made to find acceptable plans need not here be given, but it should be mentioned that the

Front view of Skull of *Arsinöitherium Zitteli*, Beadn.

Upper Eocene, Fayûm, Egypt.

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plans published by Mr. H. Woods as accepted in 1893 (*Natural Science*, vol. iii, p. 451) are not those which have been carried out, and the site has also been changed from the north to the south side of Downing Street.

The architect of both that proposed building and of the present one is Mr. T. G. Jackson, R.A., and he has had the difficult task of designing a museum which shall satisfy the needs of the Geological Department and the requirements of various University syndicates. The result is now ready to be judged; and, at any rate, the staff and students have good reason to be well pleased with their ample accommodation, and the collections will now be adequately exhibited as soon as sufficient table-cases are provided. The building is situated at the north-east corner of Downing College grounds, and consists of two wings meeting at the corner of Downing Street and Downing Place. The main wing has a frontage of 176 feet to Downing Street, and the other wing extends for the same distance along Downing Place. The court of which these wings form portions of two sides will ultimately be enclosed by the new Law Library, the Botanical Laboratory, and other University buildings. The main entrance to the Museum is from the court; a double flight of steps leads up to the first floor, on which are the palæontological collections. Each wing consists of three floors, with attics in the roof above. In the main wing at the west end of the ground floor there are the rooms for the unpacking, preparation, and setting-up of specimens, with the apartments for the curator and attendants. Shut off by folding doors from this portion is the Museum of Economics and two small research-rooms; while in the adjoining wing on the same floor are the Museum of Models and Appliances, and the principal lecture-room, capable of accommodating a class of 120 students. A special students' entrance and staircase to the floors above are placed at this point.

The first floor, to which access can be obtained directly from the court by the double flight of steps, or by an inside main staircase leading out of the Museum of Economics, is devoted to the palæontological collections, which are arranged stratigraphically in a series of bays along each side, formed by upright cases glazed above and with tiers of drawers below. Each bay is designed to contain a table-case of the ordinary type or a special show-case, while the larger specimens and additional cabinets will be arranged down the middle of the galleries. But this scheme cannot, unfortunately, be carried out at present in its entirety, owing to the funds granted by the University being insufficient by about £2,800 to provide the requisite new cases. The arrangement and display of specimens will, therefore, have to be left for the present unsatisfactory and incomplete.

The Downing Street gallery contains the Mesozoic and Tertiary fossils; its fittings and cases are of mahogany. The other wing, which has oak cases and fittings, is occupied by the Palæozoic fossils, and at its extreme end, beyond two bays devoted to Woodward's historic collection, are the Professor's private room and board-room.

At the junction of the two galleries is set the bronze statue of Prof. Sedgwick—the last work of the late Mr. Onslow Ford, R.A. The Professor is represented as standing with his geological hammer in one hand and a slab bearing the Cambrian trilobite, *Angelina Sedgwicki*, in the other.

The second floor has the western end of the Downing Street wing occupied by a well-filled library, fitted with oak shelves and book-cases through the liberality of the late Master of Trinity Hall, whose benefaction also permitted much extra ornamentation to be added to the exterior of the building. Class-rooms for palæozoology and palæobotany, private rooms for members of the staff, and a special room for the students' series of rocks and fossils are also placed on this floor in the main wing, while the Museum of Petrology, the petrological laboratory and class-room occupy the other wing.

The attics above provide space for storage of duplicate and supplementary collections, rooms for special research, lavatories, etc.

The materials which have been used in the construction of the Sedgwick Museum are very varied, but the general effect of the exterior is given by the purplish bricks made of the Weald Clay of Cranley in Surrey, mixed with 'breeze.' Bricks of a bright red colour from the Eocene clay of Castle Hedingham, and also from the Eocene beds of Bracknell in Berkshire, are here and there introduced round the arches of the windows and in other parts. The outside dressings are of Clipsham Stone from the Inferior Oolite of Rutland. Internally the local white bricks from the Gault form the mass of the building; Ancaster freestone is employed for the inside mouldings; and the Caithness Flags and the Purbeck-Portland passage beds have furnished much of the material for the staircases. Granite from Guernsey supports the internal iron columns, and Coal-measure sandstone from Idle, near Bradford, constitutes the templets on which the girders rest. The roof is covered with tiles made from the Upper Coal-measure clays of Stoke-upon-Trent. Materials obtained from many other localities and formations are used in the building, and make it in itself quite a museum of economic geology.

III.—New Carnivora from the Middle Miocene of La Grive-Saint-Alban, Isère, France.

By Dr. C. I. Forsyth Major, F.Z.S.

VIVERRIDÆ.

Progenetta certa, sp.n.

THIS is the *Progenetta incerta* of Depéret, which requires a new name, as it is far from identical with the *Mustela incerta*, Lartet, from Sansan, with which Depéret identified his specimens from La Grive.

Depéret describes and figures an inferior right m. 1, and a right maxillary portion, exhibiting the two posterior premolars, the anterior molar, and part of the alveolus of m. 2.[1] The specimen in

[1] Arch. Mus. Hist. Nat. Lyon, vol. v, pp. 34–36 (Extr.), pl. i, figs. 18–19 (1892).

the British Museum before me (M. 5555) is a portion of the right mandibular ramus with m. 1, p. 1, p. 2 in place, and the empty alveoli of the two anterior premolars. The French writer does not give the dimensions of the lower molar, the figure of which (pl. i, fig. 19) agrees in size and in shape with the corresponding molar in the British Museum. The principal cusp of the latter specimen is slightly lower, this tooth being more worn than the one in the Lyons Museum. Of the three cusps forming the talon, the one situated behind the interspace of the other two is the smallest; the external one is the highest of the three. The two premolars show, besides the principal cusp, a very low cingulum cusp at their anterior and posterior end, as well as a somewhat stronger cusp, which is more developed in the posterior premolar, above and in advance of their posterior cingulum cusp.

The '*Mustela incerta*' of Sansan has been classed in turn with the Mustelidæ and the Viverridæ. Filhol[1] comes nearest to the truth when he insists on its having more analogy with *Cephalogale*. After close examination of the description and figure of the lower carnassial of *Mustela incerta*, given by Gervais,[2] I have no hesitation in declaring it to be a member of the true Canidæ, although different generically from *Canis*.

The *Progenetta* of La Grive has *real* affinities with other known fossils. On the one hand with *Ictitherium robustum* (Nordm.). Although this has been denied by Depéret, he admits it indirectly[3] by declaring the upper sectorial of his *Progenetta* to be identical in shape with the one figured by Gervais,[4] which he believes to represent the *Mustela incerta* from Sansan, whereas, as expressly stated by Gervais, it is one of the types of Nordmann's *Thalassictis* (*Ictitherium*) *robusta* from Bessarabia.

On the other hand, the *Herpestes crassus*, Filh., from La Grive, presents such close affinities with *Progenetta* that it will have to be classed as a species of the latter. As regards the small form of '*Herpestes crassus*' described and figured by Gaillard,[5] I fail to make out any noteworthy differences, except of size, between this form and *Progenetta certa*. The one described under the same name (*Herpestes crassus*) by Depéret,[6] besides being larger than Gaillard's specimen, differs from the latter in the same characters which distinguish it from *Progenetta certa*; in Depéret's specimens the talon as well as the internal cusp of m. 1 are higher and the premolars are slightly more complex.

My conclusion is, therefore, that we have, so far, three species of *Progenetta* at La Grive, viz., (1) *Progenetta certa*, sp.n. (*Progenetta incerta*, Dep.); (2) *Progenetta crassa* (Filh.) (*Herpestes crassus*, Filh.); (3) *Progenetta Gaillardi*, sp.n. (*Herpestes crassus*, Gaill.).

[1] H. Filhol, "Etudes sur les Mammifères fossiles de Sansan": Ann. Sc. Géol., xxi, pp. 95–96 (1891).
[2] Zool. Pal. Fr., 2nd ed., pp. 221–222, pl. xxiii, fig. 3 (1859).
[3] Op. cit., p. 35.
[4] Op. cit., p. 222, text-fig. 24.
[5] Arch. Mus. Hist. Nat. Lyon, vol. vii, pp. 60–62, pl. ii, figs. 1, 3 (1899).
[6] Arch. Mus. Hist. Nat. Lyon, vol. v, pp. 31–33, pl. i, figs. 14–17 (1892).

	Measurements in millimetres.		
	Pr. certa.	*Pr. crassa.*[1]	*Pr. Gaillardi.*[2]
From posterior margin of m. 1 to anterior alveolar margin of p. 4	56	—	—
Length of m. 1	17·5	13–15	11·5
,, p. 1	14·5	11–13	9·5
,, p. 2	14	10·5–11	9
,, alveolus of p. 3	10·5	9·5	7
,, ,, p. 4	3·5	—	3
Height of mandibula below m. 1 (internal side)	18	20	15

LEPTOPLESICTIS, gen. nov.

The new genus here proposed is founded on five more or less complete mandibular rami (Brit. Mus. M. 5308; M. 5552*a–c*), ascribed to two species, one of which has been described by Gaillard[3] under the name of *Herpestes Filholi*.

In the slenderness of the teeth *Leptoplesictis* approaches the genus *Stenoplesictis* from the French Phosphorites; but its other characters assign to it decidedly a position within the Viverridæ, whilst *Stenoplesictis*, as pointed out by Schlosser, is on the border-line between the latter family and the Mustelidæ.

I have, in this place, nothing to add to Gaillard's excellent description of the larger of the two species, *Leptoplesictis Filholi* (Gaill.), which is distinguished from the smaller one, *Leptoplesictis minor*, sp.n., by the markedly higher ramus ascendens, the anterior border of which is also more vertical, as well as by the larger size. The dimension between the posterior alveolar margin of m. 1 and the anterior of p. 4 is 21·5 mm. in *L. Filholi*, against 18 mm. in *L. minor*, B.M. (M. 5552*b* and *c*).

MELIDÆ.

Trocharion albanense, gen. et sp. nov.

A portion of a right mandibula, bearing the posterior premolar and the two molars, belongs to a member of the Melidæ approaching *Mephitis* with its allies, and the Javan *Mydaus*. The teeth are low, with their cusps less pointed than in the American Skunks, but not so blunt as in the Old World genus. P. 1 is an unicuspid, conical, rather thickset tooth, with a diminutive basal cusp anteriorly, and a posterior transverse basal cingulum. The anterior margin of the principal cusp presents a sharp ridge; the posterior is broad. The first molar resembles the corresponding tooth of *Mephitis*; however, in spite of the cusps being lower than in the American Skunks, the internal margin of the crown, between the cusps, is more raised, with the result that in the fossil there are not two openings on the internal side, and we have the unusual feature of an anterior pit, similar to but less deep than the pit of the talon.

The posterior molar is oblong in shape and less reduced than in the Skunks and in *Mydaus*; it has two roots; there is a distinct

[1] The dimensions of the premolars and the height of the mandibula are taken from Depéret's figures.

[2] Dimensions given by Gaillard, op. cit., pp. 61–62.

[3] Op. cit., pp. 62–63, pl. iii, fig. 4.

talon, provided with a cusp on the internal side, and separated from the anterior portion of the tooth by an external and an internal cusp.

An isolated first upper molar probably belongs to the same species. Of known forms it can only be compared with m. 1 of *Mydaus* and the American Skunks. In general contour and some other particulars it resembles more closely *Mydaus*, but it is provided with a strong outer cingulum as in the molar of *Mephitis*, *Spilogale*, and *Conepatus*, and it is likewise more developed outside the antero-external cusp. The two outer cusps are wide apart as in all Melidæ; the internal range, composed of a large middle cusp with a smaller one on either side, agrees more with *Mydaus*, being parallel with the outer range, and not crescentic as in the American Skunks. The heel of the inner side is strongest on the postero-internal side of the tooth, without encroaching so much on the anterior side as in the Skunks.

	Measurements in mm.
From posterior part of m. 2 to anterior part of p. 1 ...	18·5
,, ,, m. 2 ,, ,, ...	4
,, ,, m. 1 ,, ,, ...	8·5
,, ,, p. 1 ,, ,, ...	6·5
Height of mandibula beneath m. 1	10
Length of upper molar	8·3
Breadth (posteriorly)	6·5

Schlosser has described[1] an isolated lower first molar, from the 'Pliocene' of Melchingen (Sigmaringen), under the name of *Promephitis Gaudryi*. This tooth closely resembles the corresponding tooth of the La Grive fossil, but the roots of the latter are not so weak, are less spreading, and there does not appear to be an anterior pit in Schlosser's specimen.

MUSTELIDÆ.

Trochictis Depereti, sp. nov.

This new species is represented by an incomplete skull with associated left mandibular ramus (Brit. Mus. M. 5313). The posterior moiety of the cranium is preserved, of the anterior portion only part of the left maxillary with the four premolars and the canine. The mandible closely resembles the one of *T. Gaudryi*, Filh.—also represented in the La Grive collection—but is smaller and slenderer. Skull depressed and elongate, with large tympanic bullæ. The temporal ridges unite to form the sagittal ridge at about ten millimetres anterior to the occiput; the space between them has, on an average, a width of about seven millimetres.

Posterior upper premolar short, with strong internal cusp extending backward beyond the middle of the tooth. This tooth much resembles the p. 1 of '*Mustela*' *Filholi*, Dep., but is shorter still. P. 2 and p. 3 are two-rooted, in the main unicuspidate, with minute basal cusps at the anterior and posterior border; p. 4 minute, with posterior basal cusp.

[1] Geol. und Pal. Abhh., v, 3, p. 32, pl. ii, figs. 14, 16 (1902).

	mm.
Length of upper p. 1	9
Transverse width of p. 1	6·5
Length of p. 2	6·5
,, p. 3	5
,, p. 4	2·5
Antero-posterior dimensions of C. at base	4
Dimensions of mandibular ramus:—	mm.
From anterior border of canine to posterior border of m. 2 ...	44·5
,, ,, ,, of condyle	51
Length of m. 1	11·5
,, p. 1	7
,, p. 2	6
,, p. 3	5

TROCHICTIS PUSILLA, sp. nov.

A diminutive species of *Trochictis* is represented by a fragmentary left mandibular ramus with m. 1 and p. 1 in place and the alveolus of m. 2. M. 1 exhibits the characteristic very elongate talon of the genus, with a delicate crenulation of the internal upper margin of the talon, as in *T. taxodon*.

m. 1 = 6 mm.
p. 1 = 3 ,,
Height of mandibular ramus below m. 1 (int.), 3·5 mm.

IV.—THE AGE OF PYRENEAN GRANITE.

By P. W. STUART-MENTEATH, Assoc. R. S. Mines.

AN easy walk from Lourdes through Lésignan, Paréac, Orincles, Leyrisse, and Bénac, to the return station of Ossun, traverses the entire outcrop of the Upper Cretaceous Flysch, lying between the abrupt uprise of the Cenomanien limestone at Lourdes and the Danien that skirts the Tertiary plain towards Tarbes. The age of this Flysch is admitted; every objection regarding it has been successively abandoned; and its appearance, composition, and characteristic fucoids are as typical at Lourdes as at any point within fifty miles on either side. By insensible gradations it passes repeatedly from fresh marly shale with characteristic fucoids into micaceous schists that have been classed as Cambrian. Portions of a sandy character acquire vivid colouring and pass insensibly into a rock indistinguishable from decomposed granulite, while preserving their original bedding. Such changes occur on either side, or on the prolongation, of extensive lenticular intrusions of solid granite, which cross the indicated route between Paréac and Orincles and between Orincles, Visker, and Bénac. Across both altered and unaltered Flysch, large and small dykes of crushed schist, filled with angular blocks of granite, quartzite, etc., vertically intrude, and increase in number and size as the granite is approached. When these dykes appear they are accompanied by thin veins of granite cutting across the Flysch. These veins gradually increase in number, and insensibly blend into the solid granite already mentioned. At Leyrisse the passage is admirably exposed in fresh road-cuttings, both on approaching the granite from Orincles and on leaving it towards Bénac. The hypothetical assumption of islands of old rock in the Flysch has been proposed and subsequently

abandoned by M. Carez as untenable; and the suggestion that some other name might be given to the granite is inconvenient, seeing that the rock in question has been recognised as granite during more than a century by every observer who has seen it.

My position in the matter differs from that of geologists who feel called upon to explain away what they suppose to be an exceptional anomaly. Since 1866, when I first studied these rocks during more than two months at Bagneres, I have traced the same phenomena throughout the Pyrenees. Around Leyrisse one sees merely a normal and usual feature of the Flysch, as I have studied that formation from St. Jean de Luz to the Corbieres. One sees completely exposed at Leyrisse a peculiar and complex mechanism of intrusion, eruption, and metamorphism, whose several features are unerringly recognisable in obscurer sections after the field-practice of many years. Its presence is verifiable in a single excursion at Leyrisse, but in some other cases has been only rendered certain by the patient researches and happy accidents of twenty years. Clearly conclusive sections and ample indications are now known to me along the entire Pyrenees. Along the hundred kilometres between Leyrisse and Iholdy the granitic penetrations of the Flysch are especially extensive and clear. Here rises the vast granitic intrusion between Iholdy and Cambo, which all recent textbooks assume to be of Archæan age. All observation, from Dufrénoy to my minutest mappings of the district, prove this granite to be as Cretaceous as its indubitable continuation to the east.

Between Suhescun and Iholdy, three miles to the south-east of the granite outcrop, the undisputed Flysch, mainly of white marl abounding in characteristic fucoids, forms a lofty ridge visibly seated on the same fossiliferous Cenomanien which similarly supports the Flysch elsewhere. Above this limestone, and in alternation with regular beds of white marl dotted with fucoids, one finds a series of great lenticles of angular breccia, mainly of ophite and quartzite, but including limestone, slate, and some fragments of granite and gneiss. Blocks of three to four yards in diameter of ophite and quartzite are conspicuous. These beds amount jointly to about 2,000 feet in thickness. They are clearly in every detail a repetition of the peculiar mechanism of Leyrisse. The ophitic character and composition are merely more prominent at this point; whereas at Leyrisse and to the west of Iholdy the granitic form predominates. Around Leyrisse the ophitic form of the same mechanism is frequently visible and soon predominant. At Iholdy the breccias pass into solid masses of ophite, and can in every detail be traced as eruptive intrusions traversing the Cenomanien limestone, and both traversing and feeding the sedimentary beds of the Flysch. No other explanation will fit the phenomena of Leyrisse and of the entire intermediate Flysch. I first discovered and classed the Pyrenean Flysch through familiarity with that of Greece, Italy, and Austria. Th. Fuchs classed that Flysch as of eruptive origin. Even in the Alpine Flysch the Taveyannaz Sandstone has been recognised as eruptive, and as analogous to Pyrenean ophites, by the only German geologist who has compared the two.

Besides the known and admitted Flysch of the Pyrenean outskirts, there is an interior Flysch which I have been gradually substituting for the Cambrian, Silurian, etc., of official maps. It faces that of Iholdy, as its corresponding southern outcrop, and presents 3,000 feet of angular blocks of every age, including fossiliferous Cenomanien; and it rests on a sheet of that Cenomanien, whose protruding points and edges have been affording me characteristic fossils for over twenty years. This conglomerate consists in great part of ophite blocks, and is crossed and penetrated by vast ophitic intrusions. Between Esterencuby and Eaux-Chaudes it is abundantly visible, and it is now admitted that the limestone on which it rests is not Cambrian but Upper Cretaceous, as I first mapped it in 1885.

Such radical admissions, along fifty miles and more, have led to the recognition that the central granite of the Pyrenees is post-Carboniferous and intrusive in synclines of Carboniferous rocks. The first of these synclines was proved by me with ample fossils in 1881. Its most certain features are figured in the map of Carez and Vasseur. The Survey geologists next represented my Carboniferous of Biriatou as pre-Cambrian, and my Trias of Vera as Carboniferous above Cambrian. In a map published in *Comptes Rendus* of June, 1894, I have shown the true relations. Their Carboniferous contains good specimens of *Radiolites foliaceus*, and their pre-Cambrian is the most typical Carboniferous in the Pyrenees. Similarly the Lourdes slates were classed as Silurian, *because* penetrated by granite, in spite of hundreds of Cretaceous Ammonites. The Cenomanien limestone of Vera, together with the Trias on which it rests, traverses the entire granite, as crystalline and graphitic marble, and emerges with Radiolites and Cretaceous corals towards San Sebastian. It is precisely analogous to the similar marble of the Cambo granite, which similarly emerges as Cenomanien. The presence of Muschelkalk, in which I have found the first Triassic fossils of the Pyrenees, is the only source of confusion to be avoided. But since 1885 sufficient fossils have enabled me to certify the presence of Cretaceous at Vera, Argelès, and elsewhere, along the synclines admittedly penetrated by granite. It must be consequently soon admitted that the granite is as little Carboniferous as Archæan. Another twenty years of useless controversy might be saved by impartial evidence on the spot. All the leading authors of the *charriage* theory have jointly exhibited their ingenuity at Biarritz in applying the resources of that theory to controvert the facts. They start from the sections of M. Carez in *Bull. Soc. Géol.* of 1896, and terminate with the final refutation of their illusions in the last published *Bulletin*. The relation of their methods to field-observation can be thus practically gauged, and it may be remarked that the clever educational manual of Commandant Barré quotes their Biarritz speculations as the most certain facts of Pyrenean geology.

St. Jean de Luz, *November* 5, 1903.

P.S.—Three recent visits to the "fundamental section" of the new and brilliant paradox of Gavarnie have convinced me that it consists of a bed of Devonian limestone with black schist both above

and below. At the point selected, east of Gèdre, there is a small diagonal fracture along which a few inches of the black schist has been squeezed in. The fallen side shows intense and irregular metamorphism at a few yards distant, and on the neighbouring high road it rests admittedly on the granite. Similarly, around the Cambo granite, the admitted Flysch which passes insensibly to granite, and which is visibly traversed by granite and ophite veins, has been figured as unconformable overlaps or outliers. The author of the Gavarnie sections especially praises the observations of Jacquot, by which nearly all the Cretaceous of his own map was formerly classed as Cambrian. By reversing the process, he preserves the proof that all previous observation was wrong.

V. — Observations on Mr. S. S. Buckman's Paper on the Toarcian of Bredon Hill.

By Professor Edward Hull, LL.D., F.R.S.

THE above paper, read before the Geological Society on the 27th May last, having just reached my hands, with the discussion,[1] I trust you will allow me to make some observations thereon, not having been present on the occasion. As my name does not appear once throughout the paper it might at first sight be considered unnecessary, if not impertinent, for me to take any direct notice of its contents. I must therefore ask permission to state the reasons for this communication as briefly as may be, and they may be summed up in a single sentence—that, being responsible as the officer of the Survey who carried out the geological mapping of the Cotteswold Hills and of the outlying Bredon Hill, I cannot allow reflections on its accuracy to pass unanswered.

It was about the year 1853 or 1854 that my chiefs, Sir R. I. Murchison and Professor Ramsay, gave me instructions to undertake the geological survey of Sheet 44 of the Ordnance Survey, with the exception of the northern portion, which was entrusted to Mr. H. H. Howell. To the south of Sheet 44, the late Mr. Bristow was engaged in mapping the Oolites in the Bath district, and for some days I had the advantage of his practised guidance in learning the details of field-surveying amongst the Oolites. I accepted the commission with enthusiasm; few more choice districts for a young geologist were available, and throughout the period, about three years, during which I had the work in hand, I enjoyed the ready help and advice of my late valued friend Dr. Thomas Wright, F.R.S., of Cheltenham. It so happened that this was the very time during which Dr. Wright was engaged in his palæontological examination of the escarpment of the Cotteswold Hills, which led to his determination of the limits of the Liassic series on the one hand, and of the Oolitic on the other. Up to the time when I commenced my survey the yellow and variegated sands of Leckhampton and Crickley Hills, near Cheltenham, of Frocester Hill, and southwards, with the "Ammonite bed" at the top, were regarded as belonging to the Inferior Oolite. But when Dr. Wright

[1] Q.J.G.S., vol. lix, p. 445.

discovered that the species of Ammonites, Nautili, and Belemnites were identical with those from the Upper Lias of Whitby, he found it impossible to resist the conclusion that the "Ammonite bed" (which he renamed the "Cephalopoda bed" in order to give it a wider signification), together with the underlying so-called "Inferior Oolite Sands," ought to be included in the Liassic rather than in the Oolitic series. Happily, about the same time D'Orbigny's work[1] made its appearance, wherein nearly all the Cephalopoda from the Ammonite bed are figured and described as "Toarcian" or Upper Lias forms, completely confirming Dr. Wright's conclusions, which were fully developed by the author in his elaborate paper "On the Palæontological and Stratigraphical Relations of the so-called Sands of the Inferior Oolite," read before the Geological Society in 1856.[2] Thus this important rectification of the succession of the Jurassic series of England was finally settled. Will it be believed that after the lapse of nearly half a century Mr. S. S. Buckman claims in his paper just published to have been the happy individual to whom the credit of so great a discovery ought to be awarded! For what does he say? It is this:—"Now that the faunal contents of the various sands are definitely known, the old, much-debated question, whether the sands are Liassic or Oolitic, may be considered as settled." The much-debated question *was* settled by Dr. Wright in 1856, and was accepted by the Geological Survey upon the publication of the memoir on the "Geology of the Country around Cheltenham" published in the year following. It is remarkable that throughout his paper, Mr. Buckman persists in calling the "Upper Lias Sands" of Wright the "Cotteswold Sands" and the "Midford Sands,"[3] the latter a name unknown to geologists in general, and adding another to the long list of fanciful names which some authors amuse themselves by inventing.

Reverting to Mr. Buckman's paper, I am perplexed to find out where the author got hold of the idea, which he says "stands in the maps and textbooks," that the beds of the *bifrontis-falciferi*, which are only 10 feet thick at Wotton, had increased to 380 feet at Bredon Hill. Do the maps and textbooks referred to include those of the Geological Survey? If they do, I venture to assure Mr. Buckman that he is entirely mistaken. The 10 feet of clay at the base of the Upper Lias at Wotton is certainly not the representative of the entire Upper Lias at Bredon Hill. The idea is too absurd to be entertained for a moment, and, as Mr. Whitaker in the discussion points out, the Survey did not profess to theorize about fossil zones. The view which I myself held, and which was that, I believe, of my colleagues of the Survey, that the sands of Wotton with the clays

[1] "Prodrome de Paléontologie Stratigraphique," t. i, ii, iii.

[2] Journ. Geol. Soc., vol. xii, p. 292. I shall not forget the day, some time in 1855, on which Dr. Wright took me up with him to Frocester Hill to collect specimens from the Cephalopoda bed which are there so abundantly stored away in nature's museum. It was a revelation to me to see forms of Ammonites, which I knew to be Upper Liassic, come forth from the base of the Oolitic cliff.

[3] [The name "Midford Sands" was given, in 1871, by Professor Phillips to the sands which occur between the Upper Lias Clay and the Inferior Oolite. (Geol. Oxford, p. 118.)—Edit. Geol. Mag.]

below were representative in time of the Upper Lias of Bredon Hill; it was a case of different sediments brought from different directions —the clays from the north, and the sands from the south or south-east, and deposited over the floor of the then sea, mingling and inosculating towards the centre of the area. Similar changes are not uncommon.

It would be interesting to know who made the statement in the discussion that "the Geological Survey maps were only intended to be lithological charts of use to agriculturalists." I cannot find any such statement; but the author in replying to it throws out an idea which could only have been listened to with amazement, that for the use of agriculturalists the superficial deposits should have been mapped first, instead of last! Imagine Sheet 44 to have been published from the Geological Survey Office in the first instance for the use of the farmers, and only containing the superficial deposits, which do not cover more than a tenth of the whole area.

I regretted much to read the words of Mr. E. T. Newton, who was in the chair (p. 462), that a map executed fifty years ago naturally required "considerable modification." There are districts to which this statement might be applied, especially those where large mining works are being carried on, but I deny that it applies to the region of the Lias and Oolites. If the field work, the tracing of boundary-lines between formations or divisions, the insertion o faults and representations of dip, strike, and similar phenomena were accurately done in the first instance, no number of years would necessitate "considerable modification." Mr. Newton is an officer of the Geological Survey and recognised as able and distinguished, and the map Sheet 44 was the work, and is issued under the authority, of the same public department. Did he, before he made the above statement from the chair of the Geological Society, satisfy himself by personal examination that the geological map of the country around Cheltenham *does* require "considerable modification"? If he replies in the affirmative I have nothing more to say, but to ascertain the points to which he refers; if not, I should have supposed that a sense of *ésprit de corps* would have prevented such a statement.

I regret very much to have found it necessary to make these remarks, but a sense of justice to the memory of a former friend, and of duty towards that important branch of the public service in which I was proud to hold various positions through forty years, have called them forth.

VI.—Notes on the Witwatersrand Beds, Transvaal.[1]

By Frederick H. Hatch, Ph.D., F.G.S., M. Inst. C.E., formerly of the Geological Survey of England and Wales.

In discussing a paper by Mr. J. S. Curtis [2] on the Witwatersrand Gold Deposits, Mr. George Denny has raised the point that the slates or shales of the Witwatersrand, which especially characterise,

[1] Abstract of a paper read before the South African Association of Engineers, Johannesburg.

[2] "The Witwatersrand Ore Deposits and their relation to the various Formations."

but are not confined to, the Lower Witwatersrand Beds (Hospital Hill Series),[1] are not of sedimentary, but of igneous origin. He relies chiefly on the fact that he has observed in places that a so-called band of slate cuts across the bedding of the quartzites. I think we are all prepared to agree with him that, where he can point out that this occurs, the rock which traverses the bedded formation must be an igneous intrusion; but such cases are rare. In the vast majority of sections where the slates are exposed, they are found to occur truly bedded, and in conformable relation with the quartzites with which they are associated. It seems to me that, after all, this is in the main a petrological question, which can be easily settled by the examination of the rocks in question under the microscope. With this end in view I have examined a number of thin sections of these rocks, in all cases prepared from the cores of boreholes, on account of the difficulty of obtaining near the surface specimens sufficiently fresh and unweathered for microscopic examination; and I have selected geological horizons which are well known on the Witwatersrand. They are (1) the band of slates which occurs in the neighbourhood of the Bird Reef Series, and (2) the slates which occur in the footwall of the Main Reef itself, in both cases in the eastern portion of the Witwatersrand, as at Van Ryn and Geduld. In all I have examined thirty sections of slates.[2]

A surprising fact is at once revealed by the microscope, viz., that the slates, both in point of composition and structure, are closely related to the quartzites with which they are associated. We find that both quartzites and slates are composed of angular to subangular fragments of quartz imbedded in a microcrystalline to cryptocrystalline ground-mass. There are occasional flakes of a yellowish-green pleochroic mica, and iron pyrites occurs abundantly as an accessory constituent. Where the slates have a greenish tinge,

[1] There is evidently some confusion existing among writers on Witwatersrand geology as to the use of the terms "Hospital Hill Series," "Hospital Hill Shales or Slates." Personally I have always used the expression "Hospital Hill Series" to include the whole of the slates and quartzites which occur in alternating belts between the outcrop of the Main Reef at Johannesburg and the granite north of the Houghton Estate ridge, or say between the City and Suburban Township and Orange Grove. In this sense the term is synonymous with "Lower Witwatersrand Beds," as used above. Others, no doubt, use the term "Hospital Hill Shales or Slates" to denote one particular belt of striped ferruginous shales which in Johannesburg is characteristically developed on the northern slope of Hospital Hill; for instance, in the Show Ground, Braamfontein. It is not so clear what is meant when the name "Hospital Hill Shales" is applied to ferruginous slates in other parts of the country (e.g. in the Heidelberg district), for although such beds belong no doubt to the Lower Witwatersrand Beds or Hospital Hill "Series," it is by no means certain that they can be correlated with that particular slate belt which occurs on the northern slope of Hospital Hill in Johannesburg; for banded ferruginous slates are not confined to one horizon in the Lower Witwatersrand Beds. Confusion would be avoided if writers would indicate whether they mean to imply the series as a whole, or a particular portion of it.

[2] I have to thank Mr. Holford, who has courteously placed at my disposal his collection of rock-sections from borehole cores from the Boksburg Gold Mines and Rand Klipfontein; Mr. D. Wilkinson, who has lent me sections from Cloverfield; and Mr. Dorffel, who has been kind enough to prepare me some sections from boreholes on Brakpan, Cloverfield, Welgedacht, Grootvlei, and other eastern farms.

this is due to the abundant presence of chlorite. The ground-mass is too minutely granular to allow of specific minerals being recognised, but it reacts under polarised light, and probably consists mainly of very finely comminuted quartz, together with a micaceous mineral, either muscovite or sericite, in minute blades. It is possible that there is also some admixture of clayey matter, kaolin or some similar mineral. No evidence of lath-shaped crystals or microlites of felspar, or augite granules, or indeed of any of the usual characteristics of igneous rocks is forthcoming. The differences observable under the microscope between quartzite and slate consist, firstly in the size of the quartz grains, and secondly in the relative proportion of quartz grains and ground-mass in the two rocks. In the quartzite, the quartz grains are fairly large and the ground-mass subordinate; in the slate, on the other hand, the quartz grains are small to minute, and the ground-mass predominant. The difference might be compared to that existing between sands and slimes, when speaking of tailings. Where a banded structure is observable in a hand-specimen of slate, under the microscope this is seen to be due solely to minute variations in texture and relative proportion of quartz granules, such as might be expected to occur under conditions of sedimentation from currents. It certainly is not 'flow-structure,' as this term is applied to igneous rocks. In short, the rocks I have examined are not igneous, but of detrital origin; or, in other words, they are true sediments of a quartzitic nature, and are correctly to be designated as slates on account of their minutely comminuted character, their banded or zonal variation due to sedimentation, and their slaty cleavage, which is of course a superimposed structure due to pressure, and may or may not be coincident with the bedding planes.

The presence of abundant iron pyrites in the slates is noteworthy, and may be due to the original sediments having contained carbonaceous matter, which subsequently acted as a reducing agent on sulphates dissolved in the circulating underground waters, sulphates being probably a common constituent of these waters.[1] The red oxides of iron, which characterise the slates when outcropping at the surface, must be products of decomposition of the pyrites. Can the decomposition of the pyrites also have given rise to specular iron and to magnetite, as these minerals also frequently occur in the surface rocks?

Another interesting feature, which I have only observed in the slates which occur in the neighbourhood of the Bird Reef (Cloverfield and Grootvlei), is the presence of rutile in innumerable minute hair-like needles or spicules, and only clearly definable by a high magnification. It is characterised by its high refractive index, straight extinction under crossed nicols, and the occasional presence of knee- and heart-shaped twins. The smallest needles appear as opaque lines on account of their needle character coupled with their high refractive index; but the larger prisms are transparent under

[1] Cf. Van Hise, "Some Principles controlling the Deposition of Ores": Trans. Amer. Inst. Min. Eng., vol. xxx (1901), p. 94.

a sufficiently high power, and then show a reddish-yellow colour. It will be interesting, and of considerable importance as a distinguishing character, should this rutile prove to be confined to the slates that occur *above* the Main Reef. There is a remarkable petrological resemblance between these slates and the phyllite of the Ardennes.[1] According to Renard, who has made a close study of the latter rocks, they are characterised by the presence of quartz, sericite, chlorite, rutile, and micaceous hematite, and these are just the minerals that characterise the Witwatersrand slates.

Although, as I have shown above, the slates are not of igneous origin, I would like to point out that rocks of true igneous origin also occur in sheets or 'flows,' interbedded with the Witwatersrand Beds. For instance, boreholes that have been put down in the extreme Eastern Rand on the farms Geduld, Welgedacht, and Grootvlei, have all intersected a sheet of amygdaloidal diabase varying in thickness from 100 to 300 feet, and situated some little distance above the Modderfontein Series. This, however, is quite different in character from the slates. Although very fine-grained or aphanitic in the hand-specimen, it can at once be distinguished under the microscope by the presence of lath-shaped felspar crystals. These are turbid through kaolinisation, and what was probably augite is now only represented by patches of chlorite. The rock therefore shows signs of considerable decomposition, which is remarkable when we consider that the specimens examined come from a great depth (2,600 feet in the Grootvlei borehole). It is, however, clearly recognisable as a diabase. Its chief characteristic in the hand-specimen is the presence of almond-shaped infilled vesicles of calcite, chlorite, and other secondary minerals. That this rock should be so decomposed at such a considerable depth below the surface bears witness to the power of circulating underground waters in effecting mineralogical changes. With regard to the main contention of Mr. Curtis's paper, viz., that the auriferous contents of the banket beds were introduced by the agency of underground waters subsequently to the deposition of the conglomerate beds, this has always been my view;[2] but it is scarcely correct to designate this as 'lateral secretion,' as Mr. Curtis does. Sandberger introduced this term in 1877 to denote the process by which the metallic contents of mineral veins had been derived from their enclosing 'country' or wall rocks.[3] It is true that in America the term has been extended to include derivation from subjacent rocks, and in this sense no doubt Mr. Curtis meant to use it.

An important fact to be borne in mind when discussing the origin of the gold in the banket is the close association of the gold with sulphide of iron in the form of pyrites. It seems to me that if it can be shown that the pyrites in the conglomerates is of secondary origin, it must also be admitted that at least the gold which is

[1] Geol. Mag., 1883, pp. 322–324 (abstract).
[2] Quart. Journ. Geol. Soc., vol. liv (1898), p. 81.
[3] Sandberger, "Zur Theorie der Bildung der Erzgänge Berg. u. Hüttenm.": Zeitung, xxxvi, Nos. 44–45.

locked up in the pyrites crystals could not have been there before the pyrites itself was formed. Rickard[1] has explained the origin of the gold in the auriferous sulphide reefs of Australasia and Colorado as being due to the presence of organic matter. It would be interesting in this connection to investigate the occurrence of a black mineral, resembling and generally supposed to be graphite, in the Rietfontein and Buffelsdoorn Mines. It has been suggested above that the presence of pyrites in the slates is perhaps due to carbonaceous matter being present in the original mud from which they were formed. The same mode of origin might be applied to the pyrites in the banket, and would also account for the precipitation of the gold in the metallic state.[2] I admit that it is difficult to understand why other conglomerate beds (Kimberley Series, Bird Reef Series, etc.), which otherwise greatly resemble the auriferous bankets, and also contain pyrites, should be poor in gold; but the conditions governing the circulation of underground waters, and the nature of the precipitating agencies likely to have been contained in the beds, are very little known to us, and there are possibilities of infinite variation in these conditions.

I have elsewhere[3] dwelt on the large amount of secondarily deposited silica which the matrix of the conglomerates contains, partly in the form of minute crystalline quartz, partly of opaline nature. It is this secondary quartz which knits the originally loosely compacted mass into a hard and almost glassy mass, almost approaching vein quartz in texture, in which the margins of the pebbles are almost obliterated, the rock breaking across matrix and pebbles indiscriminately. This silica must have been deposited from water, and is additional evidence in favour of hydrothermal agencies as a factor in the origin of our gold-reefs.

VII.—Notes on Two Points in African Geology.

By F. P. Mennell, F.G.S., Curator of the Rhodesia Museum, Bulawayo.

MR. J. E. S. MOORE'S interesting work on the "Tanganyika Problem," reviewed on p. 418 of the September number of the Geological Magazine, raises some interesting points in connection with African geology, though, as your reviewer rightly remarks, we are indebted to Mr. Moore rather for a statement of the problem "than for proposing an adequate solution of it." At the same time it must be admitted that Mr. Moore's general geological conclusions appear to me, as a worker in Africa, much more in accordance with the facts as I see them in the course of my every-day life, than the hypotheses of certain eminent geologists

[1] T. A. Rickard, "The Origin of the Gold-bearing Quartz of Bendigo Reefs": Trans. Amer. Inst., vol. xxii (1893), pp. 314–315. "The Enterprise Miné, Rico, Colorado": Trans. Amer. Inst., vol. xxvi (1897), pp. 977–979.

[2] The possibility that water-worn pellets of iron pyrites (referred to by Mr. Denny) might also occur is not excluded; yet it may be that these pellets are not water-worn, but are of concretionary origin, in which case they would probably show a radial fibrous structure.

[3] Quart. Journ. Geol. Soc., vol. liv (1898), pp. 80 and 81.

who have preceded him. There is always a great disposition on the part of visitors to a little-known country to theorise, without having had time or opportunity for making those accurate and detailed observations which are essential if deductions are to be made which will stand the test of time. And the worst of it is, 'authority' has so much weight that local workers have the utmost difficulty in removing false impressions which may thus be caused. Two points to which I may refer are the "antiquity of the African continent" and the so-called 'Rift-valleys.' Now whatever may be the antiquity of Africa as a land surface, facts are constantly coming to light which throw great doubt on its having the stability attributed to it. Fossils of Jurassic and Cretaceous age are known from numerous places, and though these are chiefly confined to the coastal fringe, fresh discoveries are frequently increasing the area, such as the recent one far inland in the Sahara. Further, though the absence of marine fossils—or, rather, of any fossils at all—from the sandstones which cover immense areas in Tropical Africa may be held to denote a lacustrine origin for the beds, it is quite possible, as Mr. Moore seems to take for granted, that they may be marine. They are largely red sandstones with intercalated lavas (basalt, etc.), and extend from the edge of the African plateau on the east to its western limit, and from the Limpopo to the Equator or near it. These beds are involved in the mountain-building on the south-east border of Rhodesia, and it thus appears possible that no mountain barrier originally existed along the east coast. Indeed, I believe the beds reach down into the low country near Sofala, where Cretaceous fossils occur. These red sandstones are particularly well developed in the Congo basin and the Zambesi basin. Mr. Moore calls them[1] the "Old African Sandstones," and considers that they underlie "Drummond's Beds." There must be some mistake here, as the latter no doubt correspond to the Permian coal-beds of Rhodesia, while the sandstones are what I have tentatively classed as of Tertiary age,[2] and extend almost continuously through Rhodesia from Lake Tanganyika to Bulawayo.

But, granted that these beds are non-marine, the freedom of the continent from extensive earth-movements does not rest on any sounder basis. The beds are largely involved in orogenic movements, not only round Lake Tanganyika, but also in Southern Rhodesia, and frequently dip at considerable angles. The great volcanic activity that they evidence is another point against stability. But the strongest argument is the insignificant amount of denudation accomplished since the great plateau has been raised to its present elevation of about a mile above sea-level. We have gently undulating or flat country with deeply scored valleys; the streams are as yet simply torrents employed in deepening their beds. They have not begun to affect the general level of the country, while falls and rapids are of frequent occurrence even in the great rivers, an

[1] "The Tanganyika Problem," p. 65.
[2] Ann. Rep. Rhodesia Museum, p. 9.

impossible state of affairs in the absence of earth-movements for long-continued periods.

The condition of things just remarked upon brings us naturally to the second point—'rift-valleys,' which have been brought forward to explain the features so obviously due to denudation having been confined to the stream-beds, with minor complications in the way of lake deposits and uplift or subsidence. It is the latter details to which the theory is primarily due, as it never seems to have occurred to anybody that slight movements of elevation or depression may cause deposition of sediments in a deep valley. The Zambesi due north of Bulawayo flows in a broad valley over a floor of Tertiary sandstones, etc., about 1,500 feet above sea-level, with Archæan schists and granite rising into hills over 4,000 feet high within a few miles. But nearer its mouth it crosses an axis of elevation which has given rise to the Shire highlands and the mountains of the Rhodesian border, as well as the Drakensberg and other ranges which have forced the rivers further south, like the Orange, to flow from close to the east coast right across the continent to the western sea. Is it not reasonable, therefore, to suppose that the Zambesi, after eroding a deep valley, was forced by elevation near the coast to deposit its sediments in a great lake which at first covered a wide area of country? Erosion would to some extent keep pace with denudation, and as the uplift was not sufficient at its maximum to reverse the course of the river, when it ceased the lake would first be confined to the original wide valley of erosion, and finally the river, as it is doing to-day, would reduce the level of its bed until it made a new one in the sediments it had itself previously deposited.[1]

No one would now argue that the Colorado cañons or the valleys of the Blue Mountains are due to anything but normal erosion; why, then, should our unfortunate African rivers be still given over to the catastrophist?

VIII.—Recent Breccias in Bolivia.

By John William Evans, Ll.B., D.Sc., F.G.S.

IN February of last year Professor Bonney read an instructive paper before the Geological Society,[2] in which he enumerated and briefly described a number of the principal breccias found in the geological series. He also gave a short description of some of the best known recent breccias—the stone rivers of the Falkland Islands and the angular detritus that fringes the foot of the hillsides in Persia, Central Asia, and Northern Hindustan. In conclusion, he expressed his opinion that most of the ancient breccias referred to in his paper indicated "a climate, arid, liable to extremes of temperature, with cold winters. The precipitation probably was

[1] In the case of undoubtedly marine sediments like those of Egypt, rapid submergence and subsequent re-elevation would account for the phenomena observed.

[2] Q.J.G.S., lviii, pp. 185–203; see also a paper by Professor Blake in the same volume, p. 290.

connected with this season, and took the form of snow." He thought, however, that in some cases "hot summers and occasional torrential rainfalls" might produce the same effects.

I have recently had an opportunity of examining an extensive breccia at the foot of the Andes and margin of the Amazonian plain, which is still in process of formation under somewhat different conditions.

In north-eastern Bolivia the Andes consist of numerous parallel ranges trending north-west and south-east. At the point where the river Beni enters the great forest plain the outer or north-eastern chain is that to which I have referred[1] as the Bala-Susi mountains. The highest summits rise to about 5,000 feet above the sea, but some of the saddles do not exceed 2,000 or 2,500 feet in altitude.

The lower slopes are clothed with trees, and from their foot, at an altitude of 650 to 1,500 feet, commences a gentle incline. This is covered with thick forest, and extends outwards for two or three miles, till, at a height of from 570 to 700 feet, it reaches the plain which stretches with scarcely a break to the mouth of the Amazon.

The mountains are composed mainly of sandstone, and the incline to which I have referred is largely made up of a breccia of the same rock, while the lower ground beyond is a tract of alluvial sand and mud.

The climate is moderately warm, the highest maximum at the foot of the mountains in the months of December and January, 1901–2, being 92·5° F., the average maximum 85°, the lowest minimum 63·2°, and the average minimum 71·5°. The average pressure of aqueous vapour was ·76″. The total rainfall in the year is probably about 90 inches, of which the greater part falls from October to April, not continuously, but mainly in torrential showers brought by south-eastern storms. There is no season completely free from rain.

The rivers that flow from the mountains to the plain rise in a lofty longitudinal valley, break through the north-eastern hills at intervals in narrow gorges, and after a steep descent reach the inclined surface of which I have spoken. I followed the Rio de Tumupasa through almost all its course; its length from its origin to the point where it leaves the mountains is rather more than three miles, during which it descends over 1,200 feet. Its bed then forms a broad road through the forest, with an irregular surface of fragments of rock of all sizes, from coarse sand-grains to angular blocks several feet in diameter. There are few rounded pebbles, though the edges of the fragments are in many cases blunted by friction.

Through this rocky tract flows at ordinary times only a small stream, and even that is found to disappear under the débris as the river is descended, leaving the broad band of rocks to continue its way down the almost imperceptible incline till, at a distance of two miles from the foot of the hills, it reaches the low-lying plain. Here it spreads out and divides into short blunt branches, and thus abruptly comes to an end.

[1] Geographical Journal, xxii, p. 601 (1903).

Beyond is nothing, except the forest with its smooth level floor of vegetable mould covered with undergrowth, scarcely a hollow to represent the river-bed.[1] Indeed, in the lower portion of the course of the stone river the fragments are in some places piled up higher than the adjoining forest soil.

The other rivers are similar in character.[2] In some cases the width of the bed of rock-fragments is much greater. Occasionally it may divide into branches, and these may again unite so as to surround an island of forest. The larger streams do not disappear, but continue beyond the end of the breccia as ordinary rivers.

In times of heavy rainfall the water from the mountains comes pouring out through the gorges, hurrying along with it the rocks that have fallen into the river-channels. When the flood reaches the forest slope, the fragments are carried on for a distance that depends on their size and the strength of the current. Rocks at least a foot in diameter may be deposited even near the end of the river of stones, for the forest and undergrowth usually keep the solid material as well as a great part of the water from diverging to one side or the other, although there may be no banks to keep them in.

When the plain, already flooded by the rains, is reached, the river spreads out, loses its current and identity as if it had entered a sea or lake, and leaves the last of its burden of sandstone blocks behind.

Much of the transport, especially of the larger fragments, takes place at the time of exceptionally great floods, and it is probable that some blocks may lie in the gorges for years till an abnormal downpour gives the rivers sufficient force to sweep them away.

After a river-bed has been raised by successive accumulations of stone fragments, the time comes when a strong flood finds it easier to take a new course in spite of the obstacles presented by the forest. Usually the river extends its bed on one side, destroying the trees that stand in the way, and leaving part of its former course to be overgrown by vegetation, or it may take an entirely different path and gradually send out a new river of stones into the forest.

By changing their courses in this way from side to side, the rivers slowly raise the level of the forest slope, with the assistance, near the foot of the mountains, of the smaller streams that flow off the side of the outer hills.

At some points the rivers cut through former accumulations of breccia, so that there is an opportunity of examining its structure. This appears to be identical with that of the material now being laid down. As would be expected, there is not much trace of stratification, though there is a tendency for the fragments to lie with their longer axes horizontal. There are few remains of the forest, for wood enclosed among the fragments and exposed to the

[1] I was told that further to the north-east at a lower level—for even the plain has a slight inclination—the stream reappears at the surface.

[2] On the road from San Buena Ventura to Tumupasa, which runs through the forest for about forty miles parallel to the mountains, I passed nineteen stone rivers, of which two were dry, besides numerous small forest streams without stones.

action of air and water, and of insects and other organisms gaining access to it through the interstices of the breccia, would soon disappear.

With the limited time and opportunities which I had, I was not able to form an exact idea of the extent of the formation. Its width is that of the slope to which I have referred—from two to three miles, perhaps more in places. The thickness must vary from point to point; it may sometimes—with interstratified beds of sand—amount to as much as five or six hundred feet. The length near Tumupasa will be equal to that of the Bala-Susi mountains, nearly a hundred miles, but breccias must be forming under exactly similar conditions in many other places at the foot of the outer ranges of the Eastern Andes.

It is sufficient for the present if I have shown that extensive breccia formations, in many respects similar to those found among the European strata, are now being accumulated in a thickly wooded, well-watered country, with a moderately warm and nearly uniform climate.

IX.—Note on *Vestinautilus crassimarginatus*, A. H. Foord.

By G. C. Crick, Assoc.R.S.M., F.G.S., of the British Museum (Natural History).

THE species *Vestinautilus crassimarginatus* was founded in 1900 by Dr. A. H. Foord [1] upon some (apparently three) specimens from the Carboniferous Limestone of Little Island, near Cork. It was described as follows:—

"Shell discoid, with slowly increasing whorls, all exposed in a deep umbilical cavity having a large central vacuity. The whorls are digonous in section, the peripheral area making a broad flattish arch; the sides, which form the steeply descending umbilicus, diverge at an obtuse angle from the margin of the latter; they are somewhat inflated in the lower half, and slightly concave in the upper, resembling those of *Vest. cariniferus* [2] in this respect. The contact or inclusion of the whorls is very slight, and, so far as can be made out from a section, there is no perceptible zone of impression. Owing to this slight amount of overlapping of the whorls, part of the peripheral area is exposed in the umbilicus, the inner whorls thus making a deep channel where they abut against those that embrace them. The umbilical border is marked by a strong, rounded rim, which becomes very prominent in the adult and senile stages.

"In the young shell the rim is about as prominent as it is in the adult of *Vest. cariniferus*, J. de C. Sow. [sp.], and other allied species. The conical apex of the young shell is ornamented with a series of close-set, fine, longitudinal ridges, and these are crossed

[1] Monograph on the Carboniferous Cephalopoda of Ireland (Pal. Soc.), pt. iii (1900), p. 79, pl. xxiii, figs. 5*a*–*c*.

[2] *Nautilus cariniferus*, J. de C. Sowerby, Min. Con., vol. v, p. 130 (1824), pl. cccclxxxii, fig. 3, excl. fig. 4. See also A. H. Foord, Mon. Carb. Ceph. Ireland (Pal. Soc.), pt. iii (1900), p. 82, pl. xxiii, figs. 1–3; pl. xxvii, figs. 2*a*, *b*.

by minute transverse striæ, which, cutting the former, impart a beautifully crenulated appearance to this part of the shell as seen under the lens. After the first whorl is passed the spiral lines begin to widen, and those of the lower half of the whorl entirely disappear, leaving five ridges, the two lower ones being very faint, till finally they all become obsolete, leaving only the transverse lines. These are regularly arranged and very numerous, their distance apart in the adult shell being almost exactly 1 mm. From the appearance presented by one of the specimens it would seem that they imbricate, but this is not very distinctly seen. They form upon the peripheral area a very distinct and deep, backwardly-directed sinus, indicating the presence of the hyponomic sinus of the aperture. On each side of the peripheral area there are three or four faint ridges in the young shell, but before the second whorl has been reached they have entirely disappeared. In a large individual in the senile stage of growth obscure folds and tubercles are developed upon the peripheral area and in one or two places upon its margin, but these are not sufficiently prominent to alter the general features of the shell.

"The septation is not known . . . .

"The siphuncle is about twice its own diameter from the peripheral margin.

"The body-chamber is imperfect in the specimen in which it is seen . . . .

"The test is rather thick, especially upon the umbilical border, where it forms the thickened rim . . . ."

In his remarks on the species the author says: "The question of the generic affinities of this shell is a difficult one to settle in the absence of a sufficient number of specimens wherewith to study the stages of growth from the very young to the old shell, and their modifications. . . . It is unfortunate that the septation is not to be got at, as this would have aided very much in the determination of the affinities of the fossil."

The dimensions given of the largest specimen (which was elliptical) known to the author are:—greatest diameter, 127 mm.; smallest diameter, 102 mm.; height, from centre of area of inclusion to centre of ventral area, 24 mm.; width, from the summit of one umbilical rim to the summit of the other, 44 mm.

Though exhibiting some differences from the figured example, there is in the British Museum a specimen (No. C. 8861) which in my opinion is referable to this species; and which, if correctly identified, adds to our knowledge of the species by revealing to some extent the form of the septal sutures; unfortunately, the locality whence the specimen was obtained has not been recorded.

The latter half of the outer whorl of the fossil is very slightly crushed, but the specimen is not otherwise distorted. The fossil is 85 mm. in diameter; it is entirely septate; the body-chamber is wanting, and a portion of the inner whorls is either absent or obscured by the matrix which covers the central vacuity; the outer whorl and nearly a half of the penultimate whorl are clearly shown,

the rest of the latter being only faintly indicated in section in the matrix; then follows a length of about 10 mm. of the antepenultimate whorl, whilst the rest of the inner whorls are entirely covered by matrix. The lateral aspect of the shell agrees very well with that given by Dr. Foord (*op. cit.*, pl. xxii, fig. 5*a*), allowance being made for the elliptical form of the figured example. The fossil shows the crenulated ornamentation of the young shell; also the subsequent spiral ridges occurring on both the lateral and the peripheral sides of the prominent umbilical margin, and which, gradually disappearing, leave only fine, well-marked transverse striæ; on the greater part of the side of the whorl these striæ are a little reclined [1]; rising with a backwardly-directed curve on to the umbilical margin, they cross the peripheral area with a very distinct and deep, backwardly-directed sinus, indicating the presence of the hyponomic sinus [2] of the aperture. On the outer whorl of the specimen this sinus is somewhat deeper and narrower than Dr. Foord's figure (fig. 5*b*) represents, but this seems to be due in part, but only in part, to the fact that the latter half of the outer whorl has been somewhat compressed laterally, sufficient, however, to force outwards the central portion of the peripheral area and eventually to fracture it. Consequently the median portion of the periphery of this part of the fossil is much more convex than is represented even in the lower part of Dr. Foord's figure (fig. 5*b*),[3] in fact the two sides of the peripheral area are inclined to each other at an angle of rather more than 100°; the peripheral area of the earlier and uncompressed part of the whorl is, however, relatively less convex. Owing to the compression already mentioned, the transverse section of the anterior end of the outer whorl of the specimen is almost pentagonal in outline, and the proportion of its dorso-ventral diameter (or height) to its transverse (or width) is greater than shown in Dr. Foord's figure (fig. 5*c*), the height, from the centre of the area of inclusion to the centre of the peripheral area, being 35 mm., and the width, from the summit of one umbilical rim to the summit of the other, 41·5 mm., the corresponding dimensions given by Dr. Foord, in an example 127 mm. in diameter, being 24 mm. and 44 mm. respectively. This proportion is rendered greater than it would naturally be by the fact that the test is imperfect on the umbilical rim on one side and entirely wanting on the other. At the anterior end of the specimen the siphuncle is seen, but owing to the compression of the whorl it is not quite in the median line; it is nearly 5 mm. in diameter, its outer surface being 10 mm. below the centre of the periphery, this being the position assigned to it by Dr. Foord; the 'zone of

[1] In the coiled shell of a Cephalopod the ribs or striæ are said to be 'direct' when their direction coincides with the radius; 'inclined' when they are forwardly-disposed in relation to a radius; and 'reclined' when they are backwardly-directed in relation to the same line.

[2] The sinus of the aperture at the median part of the peripheral area or venter indicating the position of the funnel or hyponome.

[3] It is to be noted also that the periphery in Dr. Foord's diagrammatic transverse section of the whorl (fig. 5*c*) is much less convex than it is represented at either the lower or the upper part of the front view of the fossil depicted in his fig. 5*b*.

impression,'[1] though shallow, is here well marked and about 13·5 mm. wide, but this may have been much narrower or even have entirely disappeared on the body-chamber, so that the transverse section of the body-chamber may have been more nearly digonal. Fortunately in the present specimen a few of the septa are visible, or at least partially visible; near the anterior end of the specimen they are about 6·0 mm. apart; they are, however, best displayed at about the commencement of the last third of the outer whorl, i.e. where the specimen is 69 mm. in diameter; here they are seen on a portion of the peripheral area and on a part also of the side of the whorl; on the lateral area they form a very slight backwardly-directed curve, and, crossing the umbilical rim, traverse the peripheral area in almost a straight line, or with only a very feeble backwardly-directed curve; on the periphery they are about 7·0 mm. apart. So far as can be seen, the form of the septation closely resembles that of *Vestinautilus pinguis* as figured by Dr. Foord,[2] but the chambers are a little shallower than shown in that figure. Notwithstanding the characters which differentiate this specimen from Foord's figured example, viz., the greater convexity of the peripheral area, the narrower and deeper hyponomic sinus, and the relatively greater height of the whorl in proportion to its width, there can be no doubt that the two forms are very closely allied and most probably specifically identical. In referring his species to the genus *Vestinautilus*, Dr. Foord seems, therefore, to be correct, the form of the septal sutures supporting that conclusion.

NOTICES OF MEMOIRS, ETC.

I.—Floras of the Past: their Composition and Distribution. By A. C. Seward, F.R.S., Fellow and Tutor of Emmanuel College, Lecturer on Botany in the University of Cambridge.

(*Continued from the November Number, p.* 512.)

THE geographical distribution of plants of approximately Rhætic age is shown in the following table on p. 557, which demonstrates an almost worldwide range of a vegetation of uniform character. The character of the plant-world is entirely different from that which we have described in speaking of the Palæozoic floras. Gymnosperms have ousted Vascular Cryptogams from their position of superiority; ferns, indeed, are still very abundant, but they have undergone many and striking changes, notably in the much smaller representation of the Marattiaceæ. The Palæozoic Lycopods and Calamites have gone, and in their place we have a wealth of Cycadean and Coniferous types. As we ascend to the Jurassic plant-beds the change in the vegetation is comparatively slight, and the same persistence of a well-marked type of vegetation

[1] The 'zone of impression' or 'impressed zone' is the zone which is in contact with, and impressed by, the peripheral area of the preceding whorl.

[2] *Op. jam cit.*, pl. xxv, fig. 3*a*.

extends into the Wealden period. It is a remarkable fact that after the Palæozoic floras had been replaced by those of the Mesozoic era, the vegetation maintained a striking uniformity of character, from the close of the Triassic up to the dawn of the Cretaceous era.

Mesozoic Floras.—It may be of interest to glance at some of the leading types of Mesozoic floras with a view to comparing them with their modern representatives. We are so familiar with the present position of the flowering plants in the vegetation of the world, that it is difficult for us to form a conception of a state of things in the history of the plant-kingdom in which Angiosperms had no part.

A. *Conifers.*—How may we describe the characteristic features of Rhætic and Jurassic floras? Gymnosperms, so far as we know, marked the highest level of plant-evolution. Conifers were abundant, but the majority were not members of that group to which the best known and most widely distributed modern forms belong.

A comparison of fossil and recent conifers is rendered difficult by the lack of satisfactory evidence as to the systematic position of many of the commoner types met with in Mesozoic rocks. There are, however, certain broad generalisations which we are justified in making; such genera as the Pines, Firs, Larches, and other members of the Abietineæ appear to have occupied a subordinate position during the Triassic and Jurassic eras; it is among the relics of Wealden and Lower Cretaceous floras that cones and vegetative shoots like those of recent Pines occur for the first time in a position of importance. There are several Mesozoic Conifers, to which such artificial designations as *Pagiophyllum*, *Brachyphyllum*, and others have been assigned, which cannot be referred with certainty to a particular section of the Coniferæ; these forms, however, exhibit distinct indications of a close relationship with the Araucarieæ, represented in modern floras by *Araucaria* and *Agathis*. The abundance of cones in Jurassic strata showing the characteristic features of those of recent species of *Araucaria* affords trustworthy evidence as to the antiquity of the Araucarieæ, and demonstrates their wide geographical distribution during the Mesozoic era. Additional confirmation of the important status of this section of the Coniferæ is afforded by the abundance of petrified wood exhibiting Araucarian features, in both Jurassic and Wealden rocks. There is good reason to believe that the well-known Whitby jet was formed by the alteration of blocks of Araucarian wood drifted from forest-clad slopes overlooking a Jurassic estuary that occupied the site of the moors and headlands of North-East Yorkshire.

B. *Cycads.*—One of the most striking features of the Mesozoic vegetation is the abundance and wide distribution of Cycadean plants. To-day the Cycads or Sago-Palms are represented by ten genera and about eighty species; they are plants which occupy a subordinate position in modern floras, and occur for the most part as solitary types in tropical latitudes, never growing together in sufficiently large numbers to constitute a dominant feature in the

I. Rhætic Floras.—Geographical Distribution of a few Characteristic Types.

Characteristic Types.	Arctic.						N. Temperate.			N. Sub-tropical.				Tropical.			S. Sub-tropical			S. Temperate.		
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
Equisetales																						
Equisetites Muensteri }		x					x	x		x	x					x						
Equisetites arenaceus }																						
Schizoneura								x			x	x				x		x				
Phyllotheca											x								x		x	
Filicales																						
Clathropteris }																						
Dictyophyllum }							x	x			x	x				x			x			
Laccopteris								x											x			
Todites		x					x	x			x	x				x			x		x	
Tæniopteris							x	x		x	x					x		x	x			
Thinnfeldia								x								x	x	x	x		x	
Sagenopteris							x	x											x		x	
Cycadophyta																						
Cycadites							x	x								x						
Podozamites		x					x	x			x					x						
Otozamites								x		x	x			x		x						
Anomozamites								x			x			x		x						
Pterophyllum		x					x	x			x			x		x			x		x	
Ginkgoales																						
Baiera }																						
Ginkgo }		x					x	x			x							x	x		x	

vegetation. Before the end of the Palæozoic era there existed plants bearing pinnate fronds similar to those of recent species of Cycadaceæ, and in succeeding ages the group rapidly increased in number and variety till, in the Jurassic and the early Cretaceous periods, the Cycads asserted their superiority as the leading type of vegetation. The majority of Mesozoic Cycadean fronds are assigned to artificial or form-genera as an indication of our ignorance of their reproductive organs, or of the anatomical structure of their stems. As Professor Nathorst has recently suggested, it is convenient to speak of these Cycadean remains as belonging to the group Cycadophyta. On the other hand, we find numerous petrified stems bearing well-preserved reproductive organs which enable us to compare the extinct with the existing species. We are in possession of enough facts to justify the statement that the majority of Mesozoic Cycads bore reproductive organs which differed in important morphological characters from those of existing forms. The Bennettiteæ, originally founded on a petrified stem discovered more than fifty years ago in the Isle of Wight, possessed a thick stem, clothed with an armour of persistent leaf-bases and bearing a crown of pinnate fronds, as in most modern Cycads; but their flowers, which were borne on lateral shoots, were more highly specialised than those of the true Cycads. While most of the Mesozoic Cycads were no doubt members of the Bennettiteæ, others appear to have possessed reproductive organs like those of recent species. The Bennettiteæ belong to that vast army of plants that succumbed in the struggle for existence æons before the dawn of the Recent period.

The wealth of Cycadean vegetation during the latter part of the Jurassic and the earlier stages of the Cretaceous periods is admirably illustrated by the discovery in the Black Hills of North America and in other districts of the United States of hundreds of silicified trunks of Cycadean plants. The investigations of Mr. Wieland, of Yale, who has been engaged for some time on the examination of this rich material, have already revealed the fact that in some of the Bennettiteæ the male and female organs were borne in a single flower, the female portion having a structure identical with that previously described from European stems, while the male flowers bear a close resemblance to the fertile fronds of a Marattiaceous fern.

C. *Ginkgoales.*—Before leaving the Gymnosperms a word must be said about another section—the Ginkgoales—represented by the Maidenhair-tree of China and Japan. *Ginkgo* (or *Salisburia*) *biloba* has almost, if not quite, ceased to exist in an absolutely wild state, but as a cultivated tree it has now become familiar both in America and Europe. The abundance of fossil leaves, like those of *Ginkgo biloba*, and of other slightly different forms referred to the genus *Baiera*, associated not infrequently with remains of male and female flowers, demonstrates the ubiquitous character of the Ginkgoales during the Rhætic, Jurassic, and Wealden periods. In the Jurassic shales of the Yorkshire coast, *Ginkgo* and *Baiera* leaves occur in plenty, some of them practically identical with those of the

II. Wealden Floras.—Geographical Distribution of Characteristic Types.

Characteristic Types.	Arctic.						N. Temperate.			N. Sub-tropical.				Tropical.			S. Sub-tropical			S. Temperate.		
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
Equisetales																						
Equisetites							x	x					x									
Filicales																						
Onychiopsis		x					x	x					x					x	x			
Matonidium							x	x														
Cladophlebis		x					x	x					x					x	x			
Sphenopteris							x	x										x				x
Weichselia							x	x					x									
Tæniopteris		x		x			x	x										x				
Laccopteris								x														
Gleichenites			x					x														
Ginkgoales																						
Baiera }																						
Ginkgo }		x		x	x		x	x														
Coniferales																						
Sphenolepidium		x					x	x														
Araucarites							x	x														
Pinites			x					x														
Cycadophyta																						
Nilssonia								x					x					x				
Otozamites		x						x														
Zamites							x	x					x					x				
Bennettites							x	x														

existing species. The abundance of fossil Ginkgoales in other parts of the world—in Australia, South Africa, South America, China, Japan, North America, Greenland, Franz Josef's Land, Siberia, and throughout Europe—demonstrates the former vigour of this class of plants, of which but one member survives. This type of Gymnosperm is distinctly foreshadowed in the Palæozoic vegetation, and as recently as the Eocene period a species of *Ginkgo*, indistinguishable in the form of its leaves from the living Maidenhair-tree, flourished in Western Scotland.

D. *Ferns.*—Although many of the Mesozoic ferns are preserved only in the form of sterile fronds and are of little botanical interest, several examples of fertile leaves are known which it is possible to compare with modern types. The Polypodiaceæ, representing the dominant family of recent ferns, are met with in nearly all parts of the world and possess the attributes of a group of plants at the zenith of its prosperity. We may confidently state that so far as the somewhat meagre evidence allows us to form an opinion, this family occupied a subordinate position in the composition of Mesozoic floras. Polypodiaceous sporangia have been met with in Palæozoic rocks, and their existence during the Mesozoic period is not merely a justifiable assumption, but is demonstrated by the occurrence of undoubted species of Polypodiaceæ. It seems clear, however, that this family did not attain to a position of importance until the Mesozoic vegetation gave place to that which characterises the present period. The Osmundaceæ are now represented by five species of *Todea* and four of *Osmunda*. They flourished over the greater part of Europe during the Rhætic and Jurassic periods; their remains have been recorded from England, Germany, Scandinavia, Russia, Poland, Siberia, and Greenland, also from North America, Persia, and China.

Similarly, the Schizæaceæ were among the more abundant ferns in the Jurassic vegetation. The Cyatheaceæ, a family that is now for the most part confined to the tropics, constituted another vigorous and widely spread section in the Jurassic period; we find them in Jurassic rocks of Victoria, as well as in several regions in Europe, North America, and the Arctic regions.

The fertile fronds of many of the fossil Cyatheaceæ bear a striking resemblance to that isolated survivor of the family in Juan Fernandez—*Thyrsopteris elegans*. It is true that a considerable number of ferns of Jurassic and Wealden age have been described by the generic name *Thyrsopteris* without any adequate reason; but, neglecting all doubtful forms, there remain several types represented in the Jurassic flora of Siberia, England, and other parts of the world, which enable us to refer them with confidence to the Cyatheaceæ and to compare them more particularly with the sole existing species of *Thyrsopteris*. The Gleicheniaceæ, at present characteristic of tropical and southern countries, were undoubtedly abundant in the northern hemisphere in early Cretaceous days; abundant traces of this family are recorded from Greenland as well as from more southern European latitudes.

One of the most striking facts afforded by a study of the Mesozoic fern vegetation is the former extension and vigorous development of two families, the Dipteridinæ and Matonineæ, which are now confined to a few tropical regions and represented by six species. The fertile fragment of a frond of *Matonidium* exposed by a stroke of the hammer in a piece of iron-stained limestone picked up on the beach at Haiburn Wyke (a few miles north of Scarborough), is hardly distinguishable from a pinna of the Malayan *Matonia pectinata*. Rhætic and Jurassic ferns referred to the genus *Laccopteris* afford other examples of the abundance of the Matonineæ in the northern hemisphere during the earlier part of the Mesozoic era.

The modern genus *Dipteris*, with its four species occurring in India, the Malayan region, Formosa, Fiji, and New Caledonia, stands apart from the great majority of Polypodiaceous ferns, and is now placed in a separate family—the Dipteridinæ. Like *Matonia* it is essentially an ancient and moribund type with hosts of ancestors included in such Rhætic and Jurassic genera as *Dictyophyllum*, *Camptopteris*, and others which must have been among the most conspicuous and vigorous members of the Mesozoic vegetation.

E. *Flowering Plants.*—Our retrospect of the march of plant-life has so far extended to the dawn of the Cretaceous period, a chapter in geological history written in the rocks that constitute the Wealden series of Britain exposed in the Sussex cliffs and in the Weald district of south-east England. According to the geologist's reckoning, the Cretaceous period is of comparatively modern date; it occupies a position near the summit of a long succession of ages representing an amount of time beyond the power of imagination to conceive.

One interesting fact as regards the composition of the Jurassic flora is the absence of any plants that can reasonably be identified as Angiosperms. In the Wealden flora of England no vestige of an Angiosperm has been found; this statement holds good also as regards Wealden floras in most other regions of the world. On the other hand, as soon as we ascend to strata of slightly more recent age we are confronted with a new element in the vegetation, which with amazing rapidity assumes the leading rôle. It is impossible to say with confidence at what precise period of geological history the Angiosperms appeared. When the rocks that now form the undulating country of the Weald were being accumulated as river-borne sediments on the floor of an estuary, this crowning act in the drama of plant evolution was probably being enacted.

I have already pointed out that we have as yet recognised no Angiosperms in the Wealden floras of England, Spitzbergen, Germany, France, Austria, Belgium, Russia, and Japan; but from plant-bearing rocks of Portugal, regarded as homotaxial with those which British geologists speak of as Wealden, the late Marquis of Saporta named a fragment of a leaf *Alismacites primævus*, a determination that, while possibly correct, cannot be accepted as conclusive testimony. In Virginia and Maryland there occurs a thick series of strata known as the Potomac formation, from which a rich

harvest of plant-remains has been obtained. Professor Lester Ward has recently shown that under this title are included several floras, some of which are undoubtedly homotaxial with the Wealden of Europe, while others represent the vegetation of a later phase of the Cretaceous era. From the older Potomac beds a few leaves have been assigned to Dicotyledons and referred to such genera as *Ficophyllum*, *Myrica*, *Proteæphyllum*, and others. Some of these may well be small fronds of ferns with venation characters like those of the Elk's Horn fern (*Platycerium*), while others, though presenting a close resemblance to Dicotyledonous leaves, afford insufficient data for accurate generic identification. In dealing with fossil leaves of the dicotyledonous type, we must not forget that the recent genus *Gnetum* —a gymnosperm of the section Gnetales—possesses leaves that may be said to be indistinguishable in form and venation from those of certain Dicotyledons. Before the close of the Potomac period these few fragmentary relics of possible Dicotyledons are replaced by a comparative abundance of specimens which must be accepted as undoubted Angiosperms. Previous to the discovery of the supposed Angiosperms in Wealden strata of Portugal and North America, the earliest record of an Angiosperm was represented by Heer's *Populus primæva* from Northern Greenland. This name was applied to a fragmentary specimen which may be a true dicotyledonous leaf. In 1897 Dr. White, of the Geological Survey of the United States, stated that additional examples of dicotyledonous leaves had been obtained during the visit of the Peary Arctic expedition to the well-known locality in Greenland where Heer's *Populus primæva* was discovered in the so-called Kome series. From strata known as the Atane beds, which rest on the Kome series, unmistakable Angiosperms have been collected in abundance.

Another indication of the sudden increase in the number of dicotyledons is furnished by the Dakota flora of the United States—in age somewhat more recent than the older Potomac beds. In these plant-beds it is stated that Angiosperms constitute two-thirds of the vegetation.

One of our most pressing needs is a thoroughly critical revision of the late Cretaceous and earlier Tertiary floras, with the object both of determining the systematic position of the older Angiosperms and of mapping out with greater accuracy the geographical distribution of the floras of the world in post-Wealden periods. This is a task which is sometimes said to be impossible or hardly worth the attempt; the available evidence is indeed meagre, and much of it has been treated with more respect than it deserves, but it is at least a praiseworthy aim, not to say a duty, to take stock of our material and to compile lists of plants that may bear the scrutiny of experienced systematists. We are profoundly ignorant of the means by which Nature produced this new creation; we can only emphasise the fact that in the early days of the Cretaceous era a new type was evolved which no sooner appeared than it swept all before it, and by its overmastering superiority converted the past into the present.

In conclusion, I would urge the importance of taking stock of our accumulated facts, and of so recording our observations that they

may be safely laid under contribution as aids to broad generalisations. Detailed descriptions and the enumeration of small collections are a necessity, but there is danger of the student neglecting the application of his results to problems of far-reaching import.

There is no more fascinating task than to follow the onward march of the plant-world from one stage to another and to watch the fortunes of the advancing army. We see from time to time war-worn veterans dropping from the ranks and note the constant addition of recruits, some of whom march but a short distance and fall by the way; while others, better equipped, rise to a position of importance.

At long intervals the formation is altered and the constitution of the advancing and increasing host is suddenly changed; familiar leaders are superseded by newcomers, who mark their advent by drastic reorganisation. To change the metaphor, we may compare the stages of plant-evolution to the records of changing architectural styles represented in Gothic buildings. The simple Norman arch and massive pier are replaced, with apparent suddenness, by the pointed arch and detached shafts of the thirteenth century; the latter style, which marked an architectural phase characterised by local variations subordinated to a uniformity in essential features, was replaced by one in which simplicity was superseded by elaboration, and new elements were added leading to greater complexity and a modification of plan. Similarly, the Palæozoic facies of vegetation passes with almost startling suddenness into that which monopolised the world in the Mesozoic era, and was in turn superseded by the more highly elaborated and less homogeneous vegetation of the Cretaceous and Tertiary periods. In taking a superficial view of architectural styles we are apt to lose sight of the signs of gradual transition by which one period passes into the next; so, too, in our retrospect of the changing scenes which mark the progress of plant-evolution, we easily overlook the introduction of new types and the gradual substitution of new for old. The invention of a new principle in the construction of buildings is soon followed by its wide adoption; new conceptions become stereotyped, and in a comparatively few years the whole style is altered. As a new and successful type of plant-architecture is produced it rapidly comes into prominence and acts as the most potent factor in changing the facies of a flora. Making due allowances for the imperfection of the geological record, we cannot escape from the conclusion, which is by no means opposed to our ideas of the operation of the laws governing evolutionary forces, that the state of equilibrium in the vegetable kingdom was rudely shaken during two revolutionary periods. The earlier transitional period occurred when Conifers and Cycads became firmly established, while for the second revolution the introduction of the Angiospermous type was mainly responsible. As in the half-effaced documents accessible to the student of architecture "the pedigrees of English Gothic can still be recovered," so also we are able to trace in the registers imprinted on the rocks the genealogies of existing botanical types.

II.—A Theory of the Origin of Continents and Ocean Basins.

By William Mackie, M.A., M.D.[1]

WHATEVER the conditions at present obtaining in the interior of the earth, it is naturally supposed to have originally passed through a stage which would be represented by a solid, or potentially solid, nucleus, a slowly forming and slowly thickening acid crust, with a liquid and more or less basic interstratum. At first the crust would be sufficiently flexible to accommodate itself to the tidal movements of the subjacent liquid interstratum, but when it became too rigid to admit of this tidal movement it would be broken up, the fracture probably following certain fairly defined and assignable lines. It is argued that the fragments would not have 'gone under,' but would have remained with their surfaces at a considerably higher level than the surface of the magma, and have become so fixed by consolidation of the magma around them.

It is suggested that the first great breach in the crust followed the outline of the tidal protuberance, and was, in all probability, effected at some conjunction of the sun and moon with cataclysmal suddenness, the intervening crust being shivered into small fragments, these fragments being subsequently disposed of by fusion in and incorporation with the magma. The first oval breach thus caused is the prototype of the Pacific Ocean. Further fractures, it is suggested, gave rise to the other oceans, and caused the separation of the continents. Under the influence of tidal retardation the fragments as thus blocked out became separated and finally moored at their respective distances by the solidification of the magma around them.

With the resolidification of the crust, a series of stresses was set up between the ocean basins, which consisted of the more basic, consequently specifically heavier, more quickly conducting material, and the more acid, specifically lighter, more slowly conducting continental masses. The former are, in consequence of their character and composition, the more stable portions of the resolidified crust. Further cooling therefore leads to their sinking down on the cooling and shrinking nucleus, and their elbowing aside of the continental masses, which come to be elevated in lines parallel to and extending along their margins. With further cooling the superficial layers of the continents are thrown into folds and overfolds, which would tend to find relief along the ocean margins by thrusts directed from the continents towards the oceans. Central uplifts in the continental areas also may have resulted from such pressure.

The tendency of the ocean to become deeper and the continent to become more elevated as time goes on, leads more and more to the withdrawal of the waters of the ocean (which might at first almost or altogether have covered the continental areas) from these areas, and hence to greater and greater restriction in the limits of the areas of deposit as traced from earlier to later geological times.

[1] Abstract of paper read before the British Association, Southport, Section C (Geology), September, 1903.

The origin of the Mediterranean is separately dealt with, and the cause of the unequal distribution of land and sea in the northern and southern hemispheres is discussed.

Though the contraction of the ocean basins has been the main cause of the deformation of the crust, the contraction of the continental areas has also had some share in the result. The central ridge of the Atlantic bottom may be an earth fold caused by pressure of the contiguous continental masses; but it may also be due to longitudinal fissures permitting volcanic action and consequent accumulation of volcanic products, the fissures in such case marking the relief of tension arising from the same cause.

The formation of secondary ridges parallel to the oceano-continental margins, but at some distance towards the continental side, seems to have played an important part in the evolution. Extending oceanwards in their operation they appear in some instances to have raised up portions of the ocean bottom into continuity with the land surface. In this way, with the aid of volcanic action, the ocean basins appear, in not a few instances, to have been successfully bridged. As the permanency of the master features of the globe in much their present form is a necessary corollary of the theory, such bridging of the ocean basins also becomes a necessary part of the theory, and is fairly met on the lines indicated.

Explaining as it does the general outlines of continents and ocean basins, as well as a large number of facts both in geography and geology, it is contended that the theory as sketched does represent in a general way the actual process by which the permanent features of the globe took origin.

III.—On the Lakes of the Upper Engadine. By André Delebecque.[1]

ONE of the most striking instances of a long depression forming a pass between two valleys, and occupied by a series of lakes, is to be seen in the strip of land which extends between St. Moriz and the Maloja. It is occupied by the four lakes of Sils, Silva Plana, Lampfer, and St. Moriz, with a depth of 71, 77, 34, and 44 metres respectively. The level of these lakes ranges between 1,771 and 1,800 metres. The lake of St. Moriz is obviously in a rock-basin.

As to the other three lakes, an opinion concurrently prevails which, though supported by the high authority of Professor Heim, is believed by the author to be unjustified. It is generally thought that the river Inn, weakened by the capture of some of its tributaries by the river Maira, has been unable to sweep away the deposits of the torrents descending from lateral valleys, and that consequently its waters have been dammed up into the three lakes in question.

An attentive survey of the region shows that, on the contrary, these lakes formerly constituted a single sheet of water in a rock-basin, which extended from the Maloja to the village of Lampfer, in both of which places ledges of gneiss are visible, and that the

[1] Abstract of paper read before the British Association, Southport, September, 1903, in Section C (Geology).

lateral torrents, far from contributing to the formation of the lakes, have partly filled them up by their deposits, and have divided into three what was occasionally a single basin.

The length of the original lake was remarkable, as it measured no less than 12 kilometres (7½ miles), and it must be borne in mind that though mountain lakes are often very deep their horizontal dimensions are generally limited.

As to the origin of the lake, the author is of opinion that it cannot be attributed to tectonic movements or to aqueous erosion, and that very probably glacial excavation has come into play.

IV.—Geology of the Country round Southport. By J. Lomas, A.R.C.S., F.G.S.[1]

LOOKING towards Southport from the sea, we notice three platforms rising in gigantic steps towards the east.

The first is low, varying in height from 9 to 20 feet above Ordnance datum, and is fringed on the seaward side by sandhills which rise to an elevation of from 50 to 90 feet. On the north the broad estuary of the Ribble separates this plain from a similar platform known as the Fylde district, and the Mersey on the south cuts off another fragment which forms the north end of the Wirral. Two less significant streams, the Douglas and the Alt, flow across the platform into the Ribble estuary and the Crosby Channel respectively.

The whole of this plain is the gift of the Irish Sea glacier, which formerly overrode the district, the solid rocks only reaching the surface in the case of a few islands, while the bulk is below sea-level.

In the immediate neighbourhood of Southport, Keuper marls occur. These are of great thickness, and contain bands of gypsum and pseudomorphs of rock-salt. To the north, in the Fylde district, where similar rocks occur, salt is obtained from the beds, and the boulders of gypsum which occur in great profusion in the local drift have evidently come from this formation.

The Bunter rocks of the Trias succeed to the east, and are in places capped by Keuper sandstones. Where these occur we reach the second platform.

At Ormskirk, distant about eight miles from Southport, several interesting sections show the Keuper resting on the Upper Bunter. At Scarth Hill, near the Water Tower, the relations between Keuper and Bunter are well displayed, and the quarries are worth visiting. Probably nowhere in the district do the Bunter sandstones display such clear evidence of their æolian origin. They consist of sand-grains perfectly rounded and polished, each bed containing grains of uniform size. So perfect is this sifting that it looks as if the layers had been passed through sieves of varying meshes. In some layers the grains are 2 mm. in diameter, and in others they are exceedingly fine. A comparison of these sands with others from the Sahara and

[1] Abstract of paper read before the British Association, Southport, Section C (Geology), September, 1903.

sand-dunes shows clearly the distinction between the deposition by wind agency and in water. Faults traversing the Triassic rocks conform to the general N. and S. direction so characteristic of Lancashire and Cheshire, and these are joined by E. and W. faults, which, as a rule, have little or no throw. It seems as if the N. and S. buckling which caused the main faults had cut up the rocks into blocks, and the E. and W. faults mark the units which dropped successively in the individual blocks.

Further to the east the Bunter rocks give place to Coal-measures, but at one or two places in the area, as at Skillaw Clough and Bentley Brook, thin beds of Permian age intervene.

Succeeding the Coal-measures, Millstone Grit appears in the next platform, which forms the hills above Chorley and Horwich. An outlier of Millstone Grit also occurs at Parbold, further to the west.

The disposition of the rocks already given indicate an approach towards the arch of the great Pennine anticline, and on crossing the Pennine chain a similar succession, in the reverse order, is met with in Yorkshire.

The matter is complicated, however, by the occurrence of another line of folding which shows itself in the Rosendale anticline, running E.N.E. to W.S.W.; and it is owing to this cross folding that the Millstone Grit is brought to the surface on Anglezark Moor and at Parbold.

As a result of this folding the main faults in the Carboniferous area run parallel with the anticline, and the cross faults at right angles to the faulted blocks are characterised by having only a slight throw.

Returning now to the first platform, we find the chief interest lies in the glacial and post-glacial deposits which cover the area. The surface of the Boulder-clay is very uneven, and in the hollows meres have been found. Many of these have since been filled with peat, and tree trunks, both prone and erect, are found enclosed in it. A great number of these meres, or mosses, are seen, not only about Southport, but in the Fylde, in South Lancashire, and the northern part of Cheshire.

In all cases they either drain eastwards or formerly did so. Borings in the peat show that they often extend below sea-level, and there must have existed barriers which prevented the waters from reaching the Irish Sea. It has been estimated that the coasts in the neighbourhood are being eroded, in some places at the rate of five yards a year; so that 400 years ago the land would extend more than a mile seawards; and if the same rate of waste has obtained since the Glacial period there would be a land of meres and mosses extending as far as the Isle of Man. It is possible that the Irish elk found in the Isle of Man crossed by this lost land.

Along the coast meres can be seen in all stages of decay. Immediately to the east of Southport lies Martin Mere, which is only separated from the sea by a narrow bank at Crossens. At the Alt mouth, at Leasowe, in Cheshire, and in other places, the ancient meres have been cut in two by the sea, and we have peat and tree

trunks on the coast below high-water level. These are usually spoken of as 'submerged forests,' and their occurrence in the places mentioned may indicate a lowering of the surface of the land since the trees grew.

The present mouths of the Mersey, Alt, Douglas, and Ribble have all been cut through ancient meres, and as there is evidence that these formerly drained to the east it is probable that the breaching of the meres has resulted in a reversal of flow since Glacial times, and the present mouths are of comparatively recent date.

The sandhills on the coast only occur in districts adjacent to rivers. It is probable that they owe their origin to the material brought down by the rivers, forming a bank of sand in the slack water at each side of their channels. These banks drying at low water, the sand has then been blown inland by the prevailing south-west winds. No dunes existed in this district 400 years ago, and they are probably subsequent to and result from the reversal of the drainage of the Mersey and Ribble.

V.—Diatomaceous Earth at Lake Gnangara, Western Australia.

THE Government Geologist of Western Australia reports the discovery of an extensive deposit of Diatomaceous earth at Lake Gnangara, in the Wanneroo district. It is composed almost entirely of the skeletons of Diatoms, and of the spicules of fresh-water sponges (Spongilla). The main deposit forms a quaking bog, with a smooth surface, starting immediately at the foot of the sandy banks on the northern shore of the lake at a height of a few inches above water-level, and sloping gradually towards the lake, beneath the surface of which it passes. The whole deposit is covered with a scanty growth of reeds, and, from all appearances, is still in process of formation. The deposit occupies the northern and western edges of Lake Gnangara, a permanent fresh-water lake eleven miles due north from Perth, and about four miles north-east of Wanneroo. Under the microscope, the earth is seen to be composed of a felted mass of siliceous spicules, in which are embedded numerous diatom frustules, of perfect form. They belong mainly to the groups of *Naviculeæ* and *Eunotieæ*, a very large species of *Pinnularia* being especially noticeable. The genus *Bacillaria*, which is said to yield the best dynamite, is apparently entirely absent. The Wanneroo earth would not appear to be well suited for the manufacture of dynamite, owing to the high percentage of alumina in it, and also owing to the forms of the diatoms present in it. It is, however, eminently suited for the manufacture of disinfectants by the absorption of phenol, etc., as well as for lining cold-storage rooms, and railway wagons, and as an ingredient for refrigerating paint. Owing to the extremely small percentage of iron and other mineral impurity present, it would be an excellent source of silica for the manufacture of soluble and other glass. It could also be used as an ingredient of metal-

polishing powders and soaps. For all these purposes it would require to be calcined and crushed.

VI. — A Method of Facilitating Photography of Fossils, by Gilbert van Ingen.

A SIMPLE apparatus has been devised by which a fossil of any size can be coated with a thin, opaque, white film which effectually illuminates under the influence of both colour and reflected light. The necessary articles for construction of the apparatus are: a foot-blower, large wide-mouthed bottle of gallon capacity, with three-holed rubber stopper, two bottles of quart capacity, each with two-holed rubber stopper, glass tubing of one-eighth-inch bore and rubber tubing to fit same (three feet of each), two U-shaped calcium chloride tubes filled with chloride, strong ammonia water, strong H Cl. To use: Air from the foot-blower is forced into the large bottle, which equalises the pressure, and thence through the ammonia water and H Cl into the smaller bottles. The air, mixed with the gases taken up, is passed through the calcium chloride tubes, where the moisture is extracted, and escapes through the two glass tubes held in the hands at a short distance from the object to be coated. The union of the two gases escaping from the tubes forms ammonium chloride, which settles as an exceedingly fine powder upon the surface of the specimens. The coating thus obtained, when deposited slowly, is of a dead white, which effectually hides all coloration of the surface, and, instead of obliterating the finer modelling, renders the details of the topography with the utmost distinctness. Some surfaces take the coating more readily than others. Fine-grained black limestones and all other rocks that present a velvety surface take the coating well. Porous rocks are difficult to cover. Specimens which have been handled must be washed with benzene. The coating of the salt is perfectly harmless, and may readily be removed by water, gentle heating, or the use of a soft brush. Photographs of such coated specimens fulfil more nearly the requirements of the work than do those taken by the ordinary methods. The coating is also of great assistance in the elucidation of the details of small species, as was found to advantage while studying the lobation of the heads of small trilobites.— *Annals N.Y. Acad. Sci.*, xiv, pp. 115, 116; March, 1902.

REVIEWS.

I.—Annual Reports of the Geological Commission of the Cape of Good Hope for the Years 1901 and 1902.

THESE two volumes, issued by the Department of Agriculture of the Cape of Good Hope, reach the same standard of excellence as previous publications, both with respect to the style in which they are presented and the important and interesting matter they contain.

Since the last Report the Scientific staff has undergone some change. Dr. G. S. Corstorphine retired from the Directorship in 1901, and was succeeded by Mr. A. W. Rogers under the title of

Acting Geologist, with a field staff consisting of Messrs. E. H. L. Schwarz and Alex. L. du Toit; while Miss M. Wilman acts as Museum Assistant.

The field work for the two years embraced by the Reports chiefly lay among rocks ranging in age from the Karroo formation upwards, the older rocks forming in proportion only a small amount of the area examined. The account of the Karroo beds, with their numerous and peculiar reptilian remains, and the great extent of the volcanic and igneous activity displayed, affords interesting reading. Very suggestive, too, are the remarks by Mr. Schwarz on the lavas of the Drakensberg and on the line of volcanoes trending parallel with the eastern coast, implying a line of weakness and an axis of folding in this direction. He naturally concludes that the shelving sea-shores at present existing off the southern coast may be explained by the gradual sinking of the sea-bottom without rupture, and that there is no necessity to invoke the aid of great faults.

The Cretaceous rocks and Superficial Deposits are carefully and fully described, while questions of economic importance receive due attention. A petrological account of the Rocks of Matatiele, by Mr. Schwarz, accompanies the Report for 1902, and the geological maps of parts of the Division of Matatiele and of the Igneous Rocks of Kentani, though somewhat roughly reproduced, will be found a distinct addition to the Reports.

It is a matter for congratulation that the fossils collected since the commencement of the Survey are in the hands of specialists, and that the descriptions are to be published in a special volume of the Annals of the South African Museum. We hope that good figures will accompany the descriptions.

The Report for 1901 contains an account of a journey from Swellendam to Mount Bay; a general survey of the rocks in the southern part of the Transkei and Pondoland, including a description of the Cretaceous rocks of Eastern Pondoland; and a Geological Survey of the Division of Kentani. The work, owing to the war, had to be carried on in the native reservation, instead of being continued in the Western Provinces, and this somewhat breaks the thread of previous Reports. The results obtained are, however, of considerable interest. The account of the igneous intrusions in Pondoland deserves especial attention, more particularly the following passage:—"Along the banks of the Great Kei River, north of the Bridge, there are some very fine examples of the laccolitic form of intrusion of the dolerite, but what strikes one at once is that the sedimentary rocks do not seem to have been arched up over the dome-shaped masses of igneous rocks; the contacts are not well shown, but it certainly looks as if the strata had disappeared in the space occupied by the igneous rocks, and the ends of the beds seem to abut against the rounded contours of the dolerite, a fact which we again and again noticed throughout the Territories, and which was beautifully shown in the sections of actual contacts along the Kentani coast."

Among other points of interest we may notice the description of the richly fossiliferous Cretaceous rocks (Umtamvuna Beds of Mr. Dunn's map, Izinhluzabalungu deposits of Griesbach); and the field evidence obtained as to the correlation of the Enon Conglomerate and Uitenhage Series.

The Report for 1902 contains an excellent summary of the year's work by Mr. Rogers, which consisted of an examination of the Matatiele Division by Mr. Schwarz, and parts of the Divisions of Beaufort West, Prince Albert, and Sutherland, by Messrs. Rogers and Schwarz. The account of the volcanic rocks of Matatiele by Mr. Schwarz contains much interesting matter, not the least important being the discovery of a whole series of volcanic necks in such positions as indicate that large parts of the Drakensberg and Maluti Ranges were formerly chains of volcanoes, and that they owe their elevation to these causes.

The higher parts of East Griqualand, Mr. Schwarz considers, offer a good field for the search for workable seams of coal, which would probably lie on about the same horizon as those of Indwe.

In the Western Province a nearly complete skeleton of *Pareiasaurus serridens*, weighing 700 lbs., was obtained and sent to Cape Town, where it is to be set up in the Cape Museum. Many other reptilian remains of great interest were also obtained, and the belief is expressed that the Karroo System will be satisfactorily subdivided by their means when they are sufficiently collected and described.

Not the least welcome feature of the Report for 1902 will be the following table of the classification of the Sedimentary Rocks of the Colony, of which we hope Mr. Rogers' anticipation that it will not require any considerable alteration in the near future will be realized :—

SUPERFICIAL DEPOSITS.	Dune sands, and limestone derived from them.		
	Alluvial muds, sands, and gravels near the present levels of the rivers. Laterite.		
	Estuarine deposits containing foraminifera and *Cryptodon globosus*.		
	Quartzitic rocks and ironstone gravels, representing older river deposits and laterites.		
	Pondoland Cretaceous Series.		
	Uitenhage Series.		
KARROO SYSTEM.	Stormberg Series.	Volcanic Beds.	
		Cave Sandstone.	
		Red Beds.	
		Molteno Beds.	
	Beaufort Series.		In the Transkei.
		Zone of Specialized Theriodonts.	Kentani Beds.
		Dicynodon Beds.	Idutywa Beds.
		Pareiasaurus Beds.	
	Ecca Series.	Shales and thin sandstones.	Umsikaba Beds.
		Laingsburg Beds.	
		Shales.	
	Dwyka Series.	Upper Shales.	
		Conglomerate.	
		Lower Shales.	

CAPE SYSTEM. { Witteberg Series. Bokkeveld Series. Table Mountain Series.

PRE-CAPE ROCKS:—
In the south and west of the Colony—
Ibiquas Series.
Cango Series.
Malmesbury Series.
In the north and north-west of the Colony—
Matsap Series.
Griqua Town Series.
Campbell Rand Series.
'Keis Series.
Namaqualand Schists (?).

The age of the pre-Cape Rocks (Primary of Schenck), among the different members of which two, and probably three, unconformities have been detected, is left an open question; it being only suggested that some of them may eventually prove to be of Lower Palæozoic age. We ourselves have been struck with their many resemblances to the pre-Cambrian rocks of India. The overlying, unconformable Cape System is considered to be probably the equivalent of the Lower Devonian of other countries. The classification of Schenck is adopted for the Karroo System, excepting in the separation of the Dwyka Series from the Ecca Beds. Whether the Uitenhage Series and the Cretaceous Series of Pondoland may be placed together in a Cretaceous System depends upon the results obtained by the palæontologists, who have not definitely settled the age of the Uitenhage fauna and flora. WALCOT GIBSON.

II.—PETROGRAPHISCHES PRAKTIKUM: ZWEITER TEIL: GESTEINE. By Dr. REINHOLD REINISCH. Large 8vo; pp. vii, 180. Berlin, 1904.

THIS is a practical guide to the study of rocks, written by one familiar with teaching. The characters of the several rock-forming minerals having been dealt with in the former part of the work, dated 1901, the author is able to plunge directly into the systematic description of the rocks themselves. About three-fifths of the book is devoted to the eruptive rocks, which are treated under comprehensive heads which we may call families. For each family the author gives a brief notice of the chief component minerals, the structural peculiarities, the more important types included in the family, and a selection of chemical analyses. The rather conventional arrangement is based on that of Zirkel, the principal divisions being characterized by the preponderance of alkali-felspars, of lime-soda-felspars, or of felspathoids, or by the absence of all these minerals. The discarding of the 'dyke-rocks' leads to confusion in some places, as e.g. when minette and vogesite are grouped with the orthophyres, etc. On the other hand, the distinction made in most of the families between the 'Alkali' and the 'Alkalikalk' groups is one which may profitably be impressed on the student. The practical point of view is constantly maintained

in the treatment of the rocks; but there are at the end of this section a few pages dealing with petrogenesis and chemical classification, too condensed to be of much service.

The second section, on the sedimentary rocks, is concerned with precipitates (rock-salt, etc.), tuffs, sandstones, sinters, limestones, clays, etc.; while the third is devoted to the crystalline schists, a term used in a rather wide sense to include gneisses, granulites, mica-schists, eclogites, etc.

The work, though not professing to offer original information, will be found a useful handbook of descriptive petrography. It is clearly written; and the illustrations of the micro-structures of rocks, simply designed, are well adapted to their object. The only statement which we have to quarrel with occurs on the title-page, where the publication is post-dated by some two months.

A. H.

REPORTS AND PROCEEDINGS.

Geological Society of London.

November 4th, 1903.—Sir Archibald Geikie, D.Sc., F.R.S., Vice-President, in the Chair.

The Secretary announced the presentation, by Sir John Evans, K.C.B., D.C.L., F.R.S., For. Sec. G.S., of a platinotype portrait of himself.

The following communications were read:—

1. "Metamorphism in the Loch Lomond District." By E. Hubert Cunningham-Craig, Esq., M.A., F.G.S.[1]

The area dealt with includes all the Highland rocks on either side of the Loch, as well as the area lying to the eastward, including the Trossachs. Each stage of the progressive metamorphism can be accurately determined, and each process can be studied, as a rule, without confusing its effects with those of another process. The rocks from the Leny Grit Group and the Aberfoil Slate Group show dynamic metamorphism, which increases on a higher stratigraphical horizon—the Beinn-Ledi Group; and at Rudha Mor the beginning of the thermal type is seen. This is quickly superseded by a constructive metamorphism, probably of hydrothermal type, under which, combined with, or preceded by, the increasing dynamic metamorphism, the rocks become more highly crystalline, until all clastic structures are obliterated. The segregation of like minerals into folia, the total recrystallization, and the genesis of new mineral groupings, result finally in the production of coarsely crystalline albite-gneisses from a series of fine and coarse siliceous and felspathic grits. Contact with plutonic igneous masses obliterates many of the results produced by hydrothermal, constructive, metamorphism.

[1] Communicated by permission of the Director of H.M. Geological Survey.

2. "On a New Cave on the Eastern Side of Gibraltar." By Henry Dyke Acland, Esq., F.G.S.

This cave, discovered in 1902, is situated a short distance south of the eastern end of the tunnel, which pierces the Rock from the Dockyard on the western side to 'Monkeys' Quarry' on the eastern. It was opened by blasting operations; and from the opening thus made, 88 feet above sea-level, the floor falls to the west. The main hall is about 70 feet high and 45 feet wide, and has a smooth stalagmite floor resting on breccia and a stalactitic roof covering the limestone of the Rock. Its floor falls to a point 19 feet above sea-level. The lower gallery descends at its far end to little, if anything, short of sea-level. Its floor consists of stalagmite resting on fine calcareous sand; this on coarse sand, followed by rubbly and calcareous grit, which in time rests on the rock-floor of the cave at a depth of 15 feet. In the calcareous grit are numerous well-rounded stones, some pierced by pholades. At a depth of 13 feet were echinids and barnacles. Two other galleries were explored, and in these, as in the lower gallery, the walls are pitted to a height of 28 feet above sea-level. The author concludes that the cave existed at first as a fissure, to which the sea later obtained access through a large entrance for a long period; and during this period the Rock was elevated some 42 feet. The cave was closed to the sea at a period geologically recent; and the breccia and sand-slopes at this point on the eastern side of the Rock, which are 150 feet wide and reach to a height of 200–300 feet above sea-level, date from a still more recent period.

CORRESPONDENCE.

A FINAL WORD ON FLUID INCLUSIONS.

Sir,—I am very sincerely obliged to General McMahon for his full reply to my paper on granite. I can assure him that he is mistaken in supposing my motives to be sinister.

Since the late W. Pengelly, F.R.S., in 1862, read his paper "On the Age of the Dartmoor Granites" (mark the plural), the granite problem has greatly interested local geologists, who, for forty-one years, have fought over the question with equal keenness and good temper.

General McMahon now writes, "My critic's conclusion is irreconcilable with the facts stated in my Belfast address, hence possibly his anxiety to discredit my facts under cover of an attack on the views expressed by me"! Now I never to my knowledge bolstered a theory, or sought to discredit a fact; and, so far from wishing to discredit General McMahon's facts, I should be as pleased to see his theory confirmed as anyone else's, and certainly as well as my own. With regard to my being called upon to defend my position by proving Dr. Sorby's views erroneous, I think Genera McMahon must have had in his mind Dr. Sorby's paper of 1858. My authority as to the significance of deposited chlorides is chiefly

his paper of 1876. Dr. Sorby, no doubt, showed that certain fluids are caught up during the consolidation of crystals, and I have confirmed that observation over and over again; but that established fact does not preclude the possibility of the same crystal being subsequently cracked, and a new, and perhaps an entirely different, set of fluids being introduced; and that possibly more than once.

General McMahon, in his reply, furnishes an example of the very statements which have so perplexed me; e.g., "The potential energy of water *held in a fluid state* by pressure must have been great." This was at above red heat. A few lines later we read, "I thought experts would understand that I had water in *a gaseous state* in my mind" (italics mine).

If, as General McMahon points out, Dr. Sorby proved certain inclusions to contain water, or rather salts dissolved in water, his more triumphant diagnosis was liquid carbonic acid; as he has himself observed—"people would scarcely believe that there were such things as fluid cavities in granite, and no one had imagined such a thing as liquid carbonic acid." If anyone convicts me of dissenting from Dr. Sorby's opinion on any subject on which he has all the known facts before him, I will say with the opossum, "Don't shoot, Colonel, I will come down."

I really am very sorry that my recent papers should have vexed either Professor Bonney or General McMahon. The untoward result was quite unforeseen, and shall not occur again.

A. R. Hunt.

Torquay, *November* 5, 1903.

OBITUARY.

THE REV. MAXWELL HENRY CLOSE, M.A.,

MEMB. R. I. ACAD., R.D.S., R.G.S.I., F.G.S.

Born 1822. Died September, 1903.

We regret to announce the death of the Rev. Maxwell Henry Close, Treasurer of the Royal Irish Academy, at his residence, 38, Lower Baggot Street, Dublin. Mr. Close, who had attained the venerable age of 81 years, was, up till a very short time since, daily to be seen at the Academy's house in Dawson Street. With the passing of Mr. Close a familiar figure in Dublin life has disappeared, greatly to the regret of a large circle, who knew and esteemed him for his scholarly attainments and genial personality. The son of the late Mr. Henry S. Close, Newtown Park, county Dublin, Mr. Maxwell Close was born in 1822. At a comparatively early age he entered Dublin University, where he graduated in 1846. He received the Divinity Testimonium, and in 1847 the degree of Master of Arts. In 1847 he took holy orders, becoming a priest the following year, and went to reside in England as curate of All Saints, Northampton, until 1849, when he was inducted Rector of Shangton, Leicestershire. He resigned this position eight years later, and

became curate of Weltham in the same county until 1861. Returning to Ireland, he devoted himself almost entirely to scientific and literary pursuits. In 1867 he was elected a member of the Royal Irish Academy, whose treasurer he became in 1878. A constant attendant at the stated meetings of the Academy, Mr. Close made some notable contributions to its literature, which were published in the Society's "Proceedings." Amongst the articles written by him may be mentioned his "Note on the Moon's Variation and Parallactic Inequality," which appeared in 1891, and was followed in 1901 by a paper on "Hipparchus and the Precession of the Equinoxes," and "Remarks on a Cosmographical Tractate in the Irish Language in the Library of the Royal Irish Academy." In addition he published a small work on astronomy, of which he was a keen student. He was a member of the Committee of Polite Literature of the Academy, and also a member of the Council, while his connection with the Royal Dublin Society goes back to an early date. He became a Fellow of the Geological Society of London in 1874. He was a leading member of the Royal Geological Society of Ireland, Dublin, and served as President of that body in 1878, when the first meeting of the Society was held in connection with the Royal Dublin Society. He was a contributor to the GEOLOGICAL MAGAZINE for a number of years.—Principally taken from the *Dublin Evening Mail*, Sept. 15, 1903.

The following is a list of scientific papers by the Rev. Maxwell H. Close :—

1.—"On some Striated Surfaces in the Granite near Dublin" [1863]: Dublin Geol. Soc. Journ., vol. x (1864), pp. 96–103.
2.—"Notes on the general Glaciation of the Rocks in the Neighbourhood of Dublin" [1864]: Ireland Geol. Soc. Journ., vol. i (1867), pp. 3–12.
3.—"Notes on the general Glaciation of Ireland" [1866]: Ireland Geol. Soc. Journ., vol. i (1867), pp. 207–242; GEOL. MAG., Vol. IV (1867), pp. 234–235.
4.—"On some Peculiarities in the Phenomena of Glaciation as indicating the Nature of the Agent" [1866]: Ireland Geol. Soc. Journ., vol. i (1867), pp. 287–288.
5.—"Archdeacon Pratt on M. Delaunay's Experiments on the Internal Fluidity of the Earth": GEOL. MAG., Vol. VII (1870), p. 537.
6.—"On some Corries and their Rock-basins in Kerry" [1870]: Ireland Geol. Soc. Journ., vol. ii (1871), pp. 236–249.
7.—"The elevated Shell-bearing Gravels near Dublin" [1873]: GEOL. MAG., Dec. II, Vol. I (1874), pp. 193–197; Ireland Geol. Soc. Journ., vol. iv (1877), pp. 36–40.
8.—"Concerning the Extent of Geological Time": Brit. Assoc. Rep. (1878), p. 548; GEOL. MAG., Dec. II, Vol. V (1878), pp. 450–455.
9.—"The Physical Geology of the Neighbourhood of Dublin": Dublin Soc. Sci. Proc., vol. i (1878), pp. 133–161; Ireland Geol. Soc. Journ., vol. v (1880), pp. 49–77.
10.—Anniversary Address to the Royal Geological Society of Ireland [Feb. 18, 1878]: Dublin Soc. Sci. Proc., vol. ii (1880), pp. 5–24; Ireland Geol. Soc. Journ., vol. v (1880), pp. 1–20.
11.—Anniversary Address to the Royal Geological Society of Ireland [Feb. 17, 1879]: Dublin Soc. Sci. Proc., vol. ii (1880), pp. 191–208; Ireland Geol. Soc. Journ., vol. v (1880), pp. 132–149.
12.—"On the Definition of Force as the Cause of Motion, with some of the inconveniences connected therewith" [1882]: Dublin Soc. Sci. Proc., vol. iii (1883), pp. 336–343.
13.—"On the meaning of 'Force'": Phil. Mag., vol. xv (1883), pp. 248–251.

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The Editor.

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